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ILLUMINATING ENGINEERING

Journal of the

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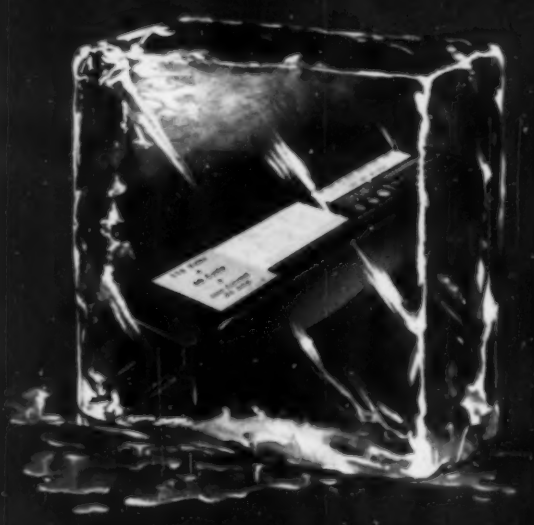

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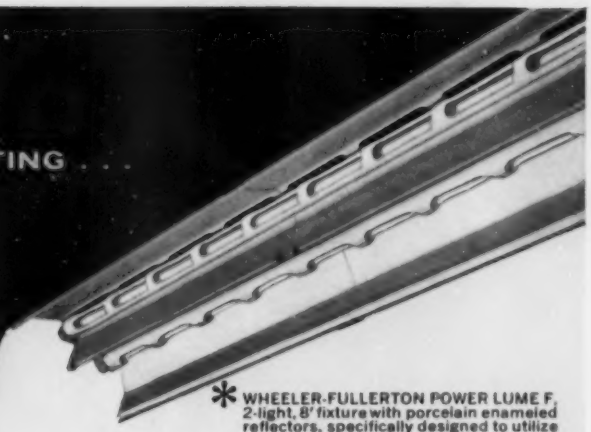

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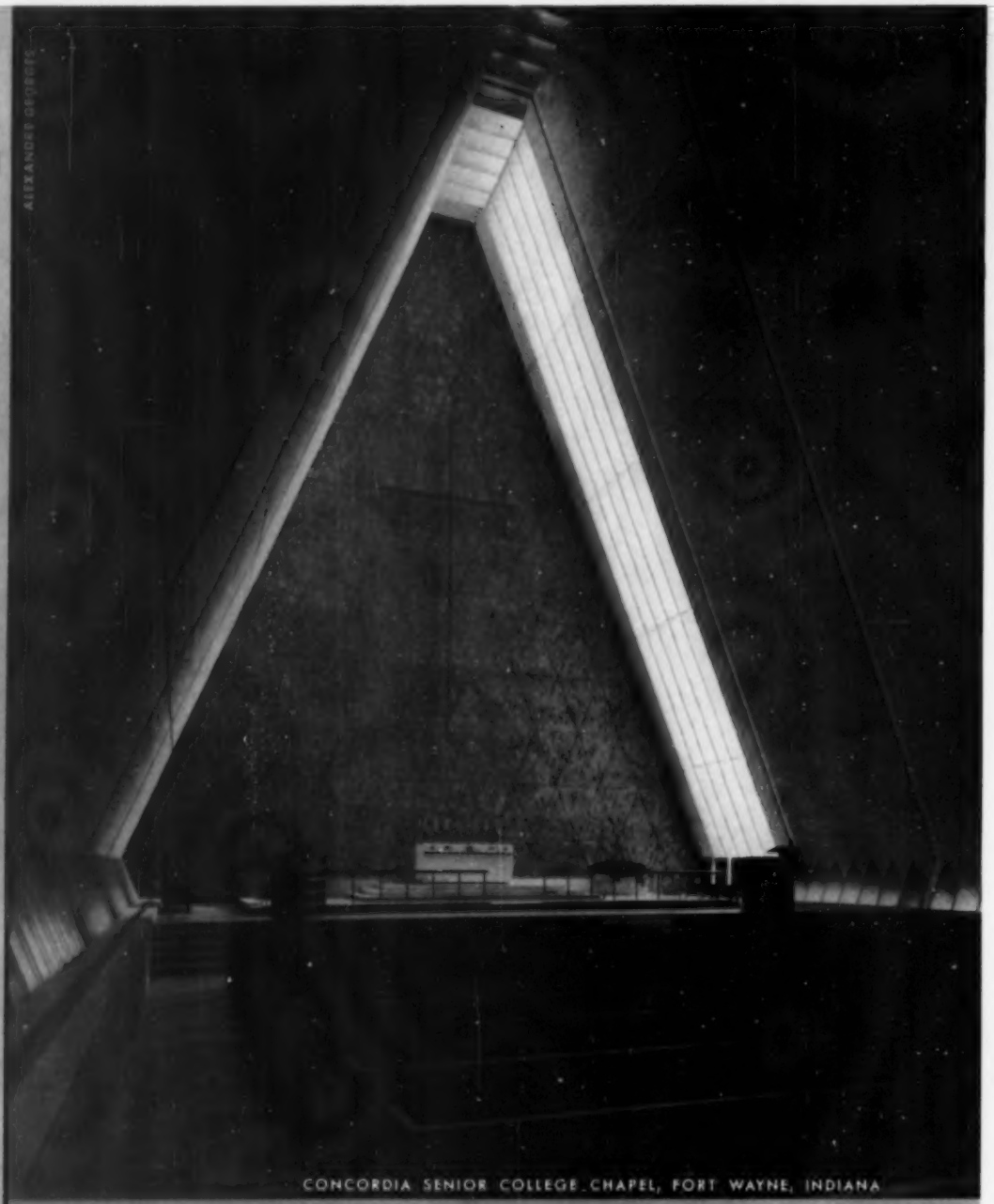

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THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

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Research notwithstanding, it has not been unusual for the practitioner to hint at a trend even before research shows why, and to what extent, that trend is necessary. MMILJ winners (and entries), through the years, have not only been good lighting jobs, but jobs with that little "extra" to distinguish them. In the 1958 contests all across the country, one of those extras was illumination levels exceeding the then-current IES recommendations. These installations, engineered with an eye toward quantity plus quality, met the new recommendations even before publication of those levels last August, and in retrospect, must be called . . .

Pace–Setting Installations

Randy's Restaurant

Flexibility was the by-word in the design of the lighting installation for the newly-built Randy's Restaurant, Covina, Calif. The owners wanted a system which could meet the needs of Randy's three types of patrons: business crowd for breakfast and lunch, teen-agers in the afternoon and families for dinner.

Separate switching of the two continuous rows of surface-mounted low brightness, large area luminaires provides 60 footcandles over the dining area with all lights on (the high level having the psychological effect of inducing rapid turnover of breakfast and lunch crowds) and a lower level of illumination for the more leisurely dinner-hour atmosphere. Luminaires are each equipped with four 96T12 standard warm white lamps; the rows mounted on seven-foot centers over the tables.

Over the ice cream bar, frequented by groups of teen-agers after school, two rows with two fixtures each are mounted on eight-foot centers to highlight the counter. Measured illumination on the work area is 125 footcandles.

This installation by G. W. Weist, Southern California Edison Co., Los Angeles, Calif., was an entry in the Southern California Section's 1958 contest for My Most Interesting Lighting Job.

With separate switching of two rows of luminaires, two light levels, for change of atmosphere, are easily obtainable in Randy's Restaurant.

Connecticut Valley Power Exchange

High level footcandle installations, in themselves, are no novelty, for it is possible to produce hundreds of footcandles simply by mounting enough luminaires side-by-side and end-to-end. The more difficult and more important task is to combine the advantages of high levels with the comfort of controlled brightness — quantity plus quality in an engineered installation. Such was the goal set — and accomplished — in the relighting of the control room of the Connecticut Valley Power Exchange, Bloomfield, Conn.

Visual tasks in the room are in two areas — on the desks and on the huge meter board and system diagram wall; hence the lighting system was designed in two parts. The general system is a luminous element in the shape of a cross, supplemented by two separate smaller square panels, deemed necessary by the irregular shape of the area. The luminous element uses two-foot square acrylic lenses resting on inverted T-bars, with continuous rows of rapid-start lamps mounted on 12-inch centers in the 15-inch plenum. With all lamps on, there is an average illumination of 206 footcandles; 230 on the desk tops. Maximum lens brightness viewed in a direction toward the board is 276 fL at 60 degrees, 109 fL at 75 degrees. On the extreme sides of the lenses, maximum brightness is 150 fL —all well below IES maximums.

The second part of the lighting system, for the meter board and system diagram wall, consists of a semi-circular arrangement of 21 recessed troffers, each equipped with three rows of 40-watt rapid-start lamps. Lamps are mounted directly over the lenses which direct the light in asymmetric patterns, distributing illumination evenly over the vertical surfaces of the meter board and system diagram wall. After 2000 hours of operation, average vertical illumination on diagram board was 92 footcandles; 90 footcandles on the meter board.

Surfaces and reflectances were carefully considered in planning the decoration of the room and the results are off-white floors, light tan walls, white ceiling, mist-gray desk tops and medium green control boards. The diagram board, because of its perforations, was made a darker shade of green than was originally intended, to reduce contrast between perforations and board surface. However, the colored tapes used on the board provide excellent contrast with the background.

Since the control room is operated 'round the clock and often sees service under emergency conditions of floods, hurricanes and ice storms, half the lighting is wired to an emergency system.

It is interesting to note that although the system operators working in the room have a choice of two levels of illumination, they prefer to have all lamps turned on all the time, getting maximum benefit from their lighting system.

This quality lighting installation, providing pleasant comfortable working conditions, a high level of controlled illumination on both vertical and horizontal planes and good brightness balance with a minimum of glare for this nerve-center of power distribution in New England won second prize in the Northeastern Regional 1958 MMILJ contest, after having taken first place in the Connecticut Section. Harold R. Young, Litecontrol Corp., Watertown, Mass., designed the system.

Good brightness ratios, light surfaces and a high level of illumination combine for a quality installation in the control room of the Connecticut Valley Power Exchange, Bloomfield, Conn.

Diesel Car Service Building

Servicing of the Budd Rail Diesel cars of the Boston and Maine Railroad in Sommerville, Mass., is done in a building containing two parallel railroad tracks, each capable of accommodating eight cars at a time. The primary service operations consist of providing sand, fuel oil, transmission oil, lubricating oil, service water, engine cooling water and hot water, in an area on the car sides extending from about two to six and a half feet above the floor. For cleaning of car interiors, illumination is required through the car windows in an area approximately seven to nine feet above ground.

The lighting installation for this building was not without its special problems. For example:

- Vertical sides of the cars had to have sufficient illumination so that all servicing could be carried on without the aid of hand lanterns or special trouble lights.
- Location of light sources could not conflict with the roof intake and exhaust ducts extending into the building, the piping along the outside walls or the various mechanical equipment indigenous to the service operation — rolling sand cars mounted on monorails parallel to the tracks and running the length of the building, and drops from some 51 reels mounted on the ceiling for the supply of water and oil.
- Exhaust fumes from the Diesel engines operating in the building cause heavy haze.
- Glare from luminaires and stainless steel car bodies had to be minimized.

In addition, the building was designed with very little headroom (it is only 17 feet high), since no overhead inspection or maintenance is required in the servic eoperation.

Tests with a mercury point source and a linear fluorescent source indicated that a fluorescent system mounted over inside and outside aisles would best suit the tasks performed. Porcelain enamelled one-piece open-ended reflectors with 10 per cent upward component were mounted in a continuous row along each of the outer aisles and in a double row, on 12-foot centers over the center aisle. The luminaires use two 8-foot high-output cool white rapid-start lamps and are equipped with ballasts for low temperature starting.

In the outside aisles the luminaires are mounted 10 feet 6 inches above the floor and tilted at an angle of 45 degrees to the vertical. Because of clearance requirements for Diesel cars, sand cars and other mechanical features, the center-aisle luminaires had to be mounted directly on the underside of the ceiling beams (about 17 feet above ground and set at an angle of 30 degrees to the vertical.

The lighting system is fed by a four-wire 277/480-volt network and the luminaires switched from three locations in the building, each location containing eight circuits. Simple and economical cleaning and relamping of luminaires is performed from the specially-designed rolling sand cars (see cut) in the center aisle and from portable rolling staging in the outside aisles.

Tests conducted under actual working conditions

Relamping from rolling sand car in center aisle.

two months after the installation of the new lighting showed illumination levels on the car sides ranging from 26-45 footcandles in the center aisle; 36-42 footcandles in the outside aisles. For cleaning of car interiors there is an average of 55 fc.

Further evidence of the quality of the installation is attested to by the fact that the glare problem has been surmounted. At no time are personnel working in the area subjected to discomforting glare.

Warren M. Reeves, assistant electrical engineer with the Boston and Maine Railroad, Boston, Mass., won first prize in the New England Section's 1958 MMILJ contest with this lighting job.

Faith Bible Church

A lighting plan keyed to the needs of the church service was the guiding principle behind the installation designed for Faith Bible Church, San Bernardino, Calif. To use light to control the focus of attention in the church and to create the desired religious atmosphere—these were the requirements of the church officials, and the achievements of the lighting engineer.

When the congregation enters the church, all lighting is on and a combination of 25 300-watt recessed downlights and eight ecclesiastical units provide 30 footcandles in the main worship area. Nine recessed downlights, also equipped with 300-watt incandescent lamps, installed over the chancel and choir areas provide 35 footcandles. But, the greatest attention, and the highest level of light is needed on the pulpit, and with the addition of two rotating spots, equipped with PAR46 lamps, 100 footcandles highlights this central area of the church.

As the pastor approaches the pulpit, the downlights in the nave ceiling are switched off, and the lighting level dimmed to five footcandles, with only the ecclesiastical units in use. Chancel and choir areas remain lighted to full intensity and the pulpit lighting can be dimmed from the maximum of 100 footcandles to any desired level. Through the use of light, attention is directed first to the minister at the pulpit, then to the surrounding choir, and an atmosphere conducive to worship has been created.

At points in the service where responsive reading is required, the downlights are switched on again, providing 30 footcandles of glare-free illumination for comfortable reading.

A complete series of catwalks is available for cleaning and relamping of all recessed equipment.

Other areas in the church, not shown here, were also lighted in line with the new IES recommendations, before those recommendations were made. Surface-mounted concentric circle lens units are used to give 40 footcandles in the classrooms, and two four-lamp large area sources provide 80 footcandles in the pastor's study.

Jack R. Adams, Southern California Edison Co., San Bernardino, Calif., designed this installation, which was entered in the Southern California Section's 1958 MMILJ contest.

View from balcony looking toward pulpit. Two surface-mounted ecclesiastical units in balcony not visible in this view.

Exterior view.

Jerold's Jewelry Store

Sparkling diamonds and crystal in an effectively lighted jewelry store window are undoubtedly one of the surest ways of making window shoppers stop and take a second look, and the 450 footcandles in the windows of Jerold's Jewelry Store contribute much to the eye-catching display.

Metal-coated glass-type window reflectors, each equipped with a 200-watt clear incandescent lamp, are recessed on 15-inch centers along the perimeter of the window to flood the tiered display ledges with light. Additional show-window illumination is from recessed fluorescent luminaires using four 40-watt white rapid-start lamps. A 12-inch soffit further conceals the equipment, so that from the shopper's point of view, the merchandise glitters from no apparent source of light.

Once the customer has been attracted by the window display, the design of the store interior (especially in an open-front store such as this) must "follow through," bring him inside and to the point of sale. Here too, the lighting plays an important role.

General lighting in this store is from 4- by 4-foot semi-recessed plastic units, each containing ten 40-watt white rapid-start lamps. Two smaller fixtures at the back of the store each use four of the 40-watt lamps and two 2- by 4-foot units at the entranceway are equipped with eight lamps each. General level of illumination from this system is 150 footcandles. Four smaller units of similar design, installed just outside the door, integrate the whole, extending the lighting design out-of-doors.

Planning of the supplementary lighting was guided by the merchandise layout—an asymmetrical lighting design for an unbalanced merchandising pattern. Along the left side and back of the store, where small items are displayed and most of the sales take place, recessed louvered downlights with 150-watt R40 spots were installed on four-foot centers. Mounted over the front edge of the display cases, the point of actual customer appraisal of the merchandise, these units direct a maximum of light into the display cases, while minimizing the veiling glare, from the customer's point of view. Two hundred footcandles, giving highlights and sparkle to the jewelry, is obtained from the combination of general and accent lighting in these areas.

Valance lighting over the wall cases on the right side of the store focuses attention on the silver and crystal display and contributes to a general feeling of spaciousness in the store. Vertical illumination on the top shelf is 210 footcandles. Cool-white fluorescent lamps are used in other display-case lighting.

Success of this installation can be measured by a reported 25 per cent increase in business during the first six months following the remodeling and relocation of the store. The owner attributes the increased business primarily to his new lighting system. Needless to say, he has learned the power of "lighting for merchandising," and is most pleased with the results.

Lighting installation for Jerold's Jewelry Store, located in a Connecticut shopping center, was by C. E. Johannsen, United Illuminating Co., New Haven, Conn. The installation won second prize in the Connecticut Section's 1958 My Most Interesting Lighting Job contest.

Interior view showing general and accent lighting systems.

Effective Intensity of Certain Types of Rotating Beacons

By LT. M. R. WOHLERS
ENS. H. A. LEUPP

THE ANGULAR distribution of intensity produced by certain types of rotating beacons may be represented by the following expression:[1]

$$I = I_o e^{-K(\psi-\psi_o)^2} \qquad (1)$$

where I_o is the peak value of intensity occurring on the axis of symmetry ψ_o, and I is the value of intensity at an angle ψ from the axis of symmetry. If the beacon is rotated with the constant velocity of r revolutions per minute the expression becomes

$$I = I_o e^{-K[\pi/30 r(t-t_o)]^2} \qquad (2)$$

where t_o is the point in time (seconds) when the beacon is producing the intensity I_o in the direction of an observer, and t is the point in time (seconds) when the beacon is producing the intensity I in the direction of the same observer. In order to determine the apparent or effective intensity of this light when it is viewed as a point source at threshold, the expression for I given by (2) is substituted in the Blondel-Rey equation:[2, 3]

$$I_e = \frac{I_o \int_{t_1}^{t_2} e^{-K[\pi/30 r(t-t_o)]^2} dt}{(t_2-t_1)+0.2} \qquad (3)$$

where the limits of integration t_1 and t_2 are selected in such a way that $I(t_1) = I(t_2)$ and the value of I_e obtained is a maximum for any given I_o, K, and r (Fig. 1). This can be shown to be at the point where $I = I_e$.[3]

Since $I_o e^{-K[\pi/30 r(t-t_o)]^2}$ is symmetrical about t_o; $t_o - t_1 = t_2 - t_o$ and $t_1 = 2t_o - t_2$.

The intent of this article is to provide a means of obtaining the I_e for given values of I, K, and r which does not require a trial and error solution of the integral equation given by (3). The approach taken is to reduce Equation (3) to a function of r, K, and (t_2-t_o), then differentiating this expression with respect to (t_2-t_o) holding r and K constant to determine an expression for (t_2-t_o) which maximizes equation (3). As noted on Fig. 1, t_1 is related to t_2 by the symmetry of the curve. Therefore, substituting for t_1 in terms of t_2 Equation (3) becomes:

$$I_e = \frac{I_o \int_{2t_o-t_2}^{t_2} e^{-K[\pi/30 r(t-t_o)]^2} dt}{2(t_2-t_o)+0.2} \qquad (4)$$

This may be simplified further by making the substitution $u = \pi/30 r\sqrt{K}(t-t_o)$ in the integral:

$$I_e = \frac{\frac{15}{\pi r\sqrt{K}} I_o \int_{\pi/30 r\sqrt{K}(t_o-t_2)}^{\pi/30 r\sqrt{K}(t_2-t_o)} e^{-u^2} du}{(t_2-t_o)+0.1} \qquad (5)$$

Let $(t_2-t_o) = \Delta t$ and note that the integrand is symmetric about $u = 0$. Therefore the value of the integral will be twice that taken over half of the curve:

$$I_e = \frac{\frac{30}{\pi r\sqrt{K}} I_o \int_o^{\pi/30 r\sqrt{K}\Delta t} e^{-u^2} du}{\Delta t+0.1} \qquad (6)$$

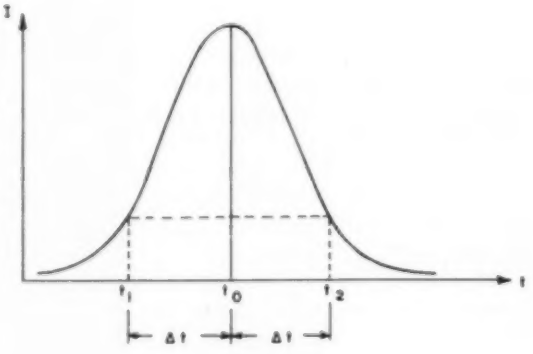


Figure 1.

AUTHORS: United States Coast Guard Headquarters (ECV), Washington, D. C.

TABLE I.

$\frac{\pi}{30} r\sqrt{K}\Delta t$	$\frac{\pi}{30} r\sqrt{K}$	Δt	$r\sqrt{K}$	$\frac{I_e}{I_o}$
0.15	0.0227	6.61	0.217	0.981
0.20	0.0542	3.69	0.518	0.963
0.30	0.187	1.60	1.79	0.915
0.40	0.456	0.877	4.35	0.854
0.50	0.924	0.541	8.82	0.781
0.60	1.67	0.359	15.9	0.702
0.70	2.80	0.250	26.7	0.614
0.80	4.46	0.179	42.6	0.526
0.90	6.88	0.131	65.7	0.446
1.0	10.3	0.0971	98.4	0.366
1.1	15.2	0.0724	145	0.298
1.2	22.0	0.0545	210	0.239
1.3	31.8	0.0409	304	0.184
1.4	45.8	0.0306	437	0.141
1.5	66.2	0.0227	632	0.106
1.6	96.0	0.0167	917	0.0768
1.8	206	0.00874	1970	0.0391
2.0	462	0.00433	4410	0.0183

Finally, since the integral is now in the form of $\sqrt{\pi/2}$ times the error function, $E_2(x)$;[4] Equation (6) may be written:

$$I_e = \frac{\frac{15}{\sqrt{\pi}} \; I_o E_2\left(\frac{\pi r\sqrt{K}}{30} \; \Delta t\right)}{r\sqrt{K}\,(\Delta t + 0.1)} \qquad (7)$$

Equation (7) can be used to calculate the effective intensity (I_e) in terms of any given I_o, r, and K if the value of Δt is known. As discussed above, an expression for Δt or $(t_2 - t_o)$ may be obtained by differentiating (7) with respect to Δt and setting this equal to zero:

$$\frac{dI_e}{d\Delta t} = \frac{15 I_o}{\sqrt{\pi} r\sqrt{K}}\left[\frac{(\Delta t+0.1)\frac{\sqrt{\pi} r\sqrt{K}}{15} e^{-(\pi/30 r\sqrt{K}\Delta t)^2} - E_2\left(\frac{\pi r\sqrt{K}}{30}\Delta t\right)}{(\Delta t+0.1)^2}\right] = 0$$

$$\text{or} \quad E_2(\pi/30 r\sqrt{K}\Delta t) = \frac{\sqrt{\pi} r\sqrt{K}}{15}(\Delta t+0.1)\, e^{-(\pi/30 r\sqrt{K}\Delta t)^2} \qquad (8)$$

One method of solving this expression for Δt in terms of $r\sqrt{K}$ is to use (8) to obtain $\pi/30 r\sqrt{K}$ as a function of $\pi/30 r\sqrt{K}\Delta t$,

$$\pi/30 r\sqrt{K} = \frac{\sqrt{\pi} E_2(\pi/30 r\sqrt{K}\Delta t) - 2(\pi/30 r\sqrt{K}\Delta t)\, e^{-(\pi/30 r\sqrt{K}\Delta t)^2}}{(0.2)\, e^{-(\pi/30 r\sqrt{K}\Delta t)^2}} \qquad (9)$$

then assume values of $\pi/30 r\sqrt{K}\Delta t$ and compute $\pi/30 r\sqrt{K}$. The Δt's obtained by dividing the resulting paired values can then be used to determine I_e/I_o for corresponding values of $r\sqrt{K}$ (Equation 7). The results of these calculations are tabulated in Table I and are plotted on Fig. 2 so that for any given $r\sqrt{K}$ between 0.22 and 4400, the corresponding I_e/I_o can be found.

In applying these results, it is necessary to obtain the value of K from the distribution curve. This is determined as follows: letting $\psi_o = 0$, Equation (1) may be rearranged so that:

$$I/I_o = e^{-K\psi^2} \qquad (10)$$

therefore $K\psi^2 = 1$ for that value of ψ, say ψ_a, at which $I/I_o = 1/e$ thus $K = 1/\psi_a^2$ (11)

The results tabulated in Table I and shown in Fig. 2 can be applied directly to any apparatus whose intensity distribution curve may be represented by Equation (1). It appears that the method may also be applied with reasonable accuracy to beacons whose intensity distribution departs from the ideal curve. In these cases K is obtained from (11) by substituting for ψ_a the average of the two values for which $I/I_o = 1/e$. This procedure is illustrated on Figs. 3, 4 and 5 for three different rotating beacons. The corresponding I_e/I_o for several different speeds between $^1/_{12}$ and 12 rpm were obtained by both the exact method[3] and the approximate one described above.

Conclusion

The problem of determining the effective intensity of a rotating beacon whose intensity distribution curve is given by $I = I_o e^{-K\psi^2}$ has been solved;

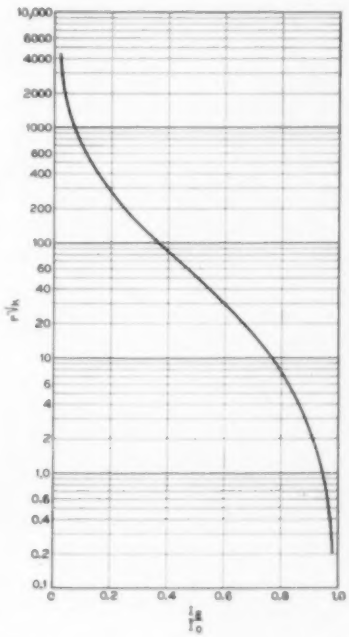
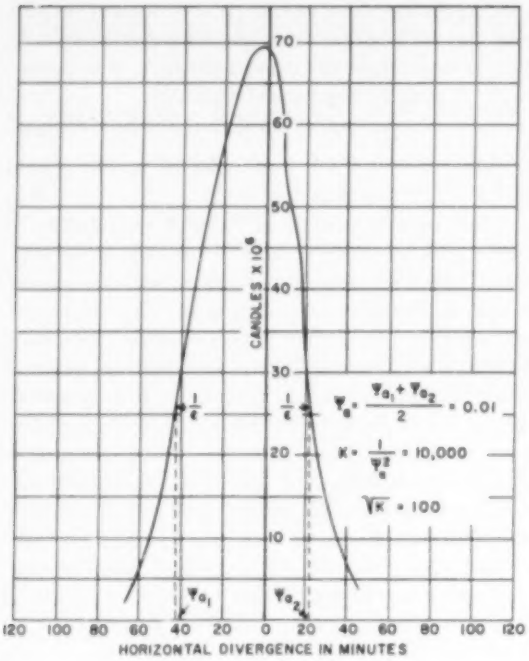


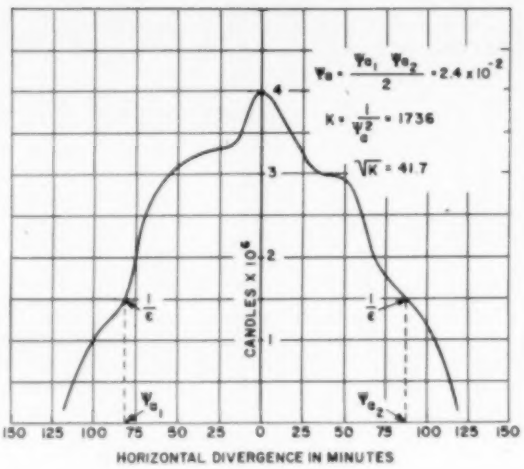
Figure 2. Plot of I_e/I_o as a function of $r\sqrt{K}$.



I_c/I_o

RPM	Actual	From Curve in Fig. 2
1/12	0.79	0.79
1/3	0.58	0.58
1	0.36	0.36
3	0.18	0.19
6	0.11	0.11
12	0.06	0.06

Figure 3. 2500-watt short arc lamp in 36-inch diameter semi-precision grade parabolic mirror.



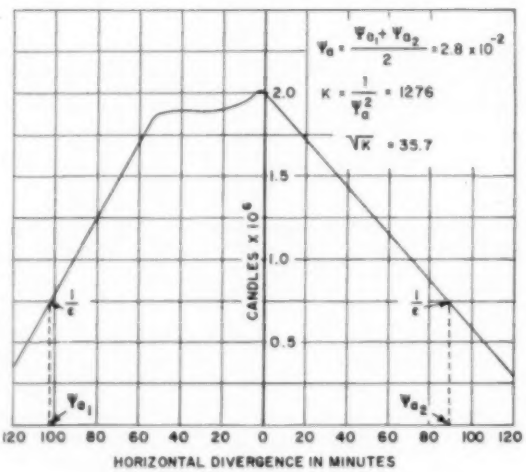
I_c/I_o

RPM	Actual	From Curve in Fig. 2
1/12	0.81	0.87
1/3	0.69	0.72
1	0.53	0.53
3	0.32	0.32
6	0.21	0.21
12	0.13	0.13

Figure 4. 1000-watt C-13 120-volt 24-inch precision grade parabolic mirror.

the results are in the form of a curve of I_c/I_o versus $r\sqrt{K}$ where r is the speed of rotation. Three examples have been given which indicate that in certain cases the results may be used with reasonable accuracy to obtain the effective intensity of beacons whose intensity distribution departs from the ideal curve.

The opinions contained herein are the private ones of the writers and are not to be construed as official or reflecting the views of the Commandant or the Coast Guard at large.



I_c/I_o

RPM	Actual	From Curve in Fig. 2
1/12	0.88	0.88
1/3	0.73	0.74
1	0.56	0.56
3	0.35	0.35
6	0.23	0.23
12	0.14	0.14

Figure 5. Type DCB-36 36-inch rotating airport beacon; 1000-watt C-13 30-volt lamp.

References

1. Chesterman, W. D., and Stiles, W. S.: "The Visibility of Targets in a Naval Searchlight Beam," *Symposium on Searchlights*, London, Illuminating Engineering Society, pp. 75-102, 1948.

2. Projector, T. H.: "Effective Intensity of Flashing Lights," ILLUMINATING ENGINEERING, Vol. LII, No. 12 (December 1957).

3. Douglas, Charles A.: "Computation of the Effective Intensity of Flashing Lights," ILLUMINATING ENGINEERING, Vol. LII, No. 12 (December 1957).

4. Jahnke and Emde: *Tables of Functions with Formulas and Curves*, B. G. Tuebner, Leipzig and Berlin, 1938; G. E. Stechert, New York, N. Y., pp. 23-24.

Figure 1. The new Coast Guard lighthouse at Oak Island, N. C.

The Coast Guard Lights A New Lighthouse

By LT. J. E. WESLER, USCG

In his recent article in ILLUMINATING ENGINEERING,[1] F. C. Breckenridge traced the art of signal lighting through the fifty-year period to and including 1955. The purpose of the present article is to present briefly the latest development in the oldest field of this art — that of lighted aids to marine navigation. This installation might have been an extremely unusual entry in the My Most Interesting Lighting Job contest of the IES, if the project had been the work of only one man, instead of the coordinated effort of many that it was.

In planning the relocation of the Cape Fear Light to Oak Island, North Carolina, for practical reasons of economy of maintenance, consolidation of units, and convenience, the need for an improved lighthouse beacon soon became apparent. Available equipment either did not provide the effective intensity to furnish the desired level of performance as a reference mark for marine navigation, or was unsuitable for reliable, relatively maintenance-free, and remotely controlled operation. Thus, mothered by necessity, a new lighthouse beacon was developed, and installed.

The newly constructed lighthouse at Oak Island, North Carolina, shown in Fig. 1, went into normal operation on May 15, 1958. This 145-foot high tower serves to support a revolving beacon producing four beams of light, each with a measured intensity of 70,000,000 peak candlepower. The beacon consists essentially of four 36-inch searchlight casings mounted on a rotating platform, and oriented so that each beam is separated by 36 degrees from the adjacent beam. Revolving at 6 rpm, this beacon provides a coded characteristic described as Group Flashing White, four every ten seconds. That is, every ten seconds a group of four flashes appears to a mariner at a distance, with each individual flash within each group appearing one second apart. The light sources are 2500-watt short-arc mercury lamps. Fig. 2 shows the beacon as it was assembled at the Coast Guard Yard, Baltimore, Maryland, prior to shipment to

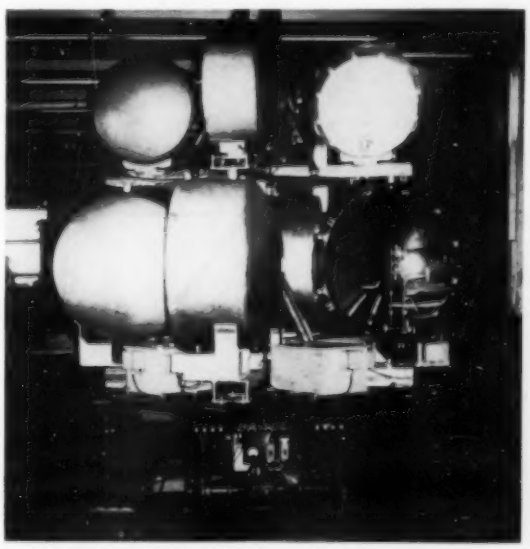


Figure 2. New lighthouse beacon, designed by the Coast Guard. Note that the searchlights have not as yet been oriented at the required 36-degree separation.

AUTHOR: United States Coast Guard Headquarters, Civil Engineering Division, Washington 25, D. C. The assertions and opinions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Commandant or the Coast Guard at large.

the site at Oak Island. Note that the lights have not yet been oriented at the required 36-degree separation. Fig. 3 is the photometric trace of the candlepower distribution produced by one of the 36-inch reflector and 2500-watt short-arc combinations, as measured by the Coast Guard's Field Testing and Development Unit. When rotated at 6 rpm, the effective intensity of this beacon, after correction for Blondel-Rey effect and the presence of lantern panes in the lighthouse, is advertised as 14,000,000 effective candlepower.

Fig. 2 shows an upper bank of smaller lights on the new beacon, also. During fair and good conditions of visibility, the full 14,000,000 effective candlepower light is not needed to provide a useful aid to marine navigation. And so, for economy of operation, a second bank of four 24-inch searchlight casings, each with a 1000-watt incandescent lamp, was added. Each 24-inch light is mounted above a 36-inch light and is oriented parallel with the larger light. Thus, no matter which bank of lights is in use, the same flashing characteristic is exhibited for identification purposes. The effective intensity of the smaller bank of lights has been determined to be 1,400,000 effective candlepower.

The beacon is wired for remote control from the base, to eliminate frequent climbing of the tall tower. Selection of the upper or lower bank of lights may also be made from the base. Which bank of lights to be used is determined by nearby Coast Guardsmen who note the appearance of a reference light, situated approximately four miles away. The intensity of this reference light has been chosen so that when visibility conditions

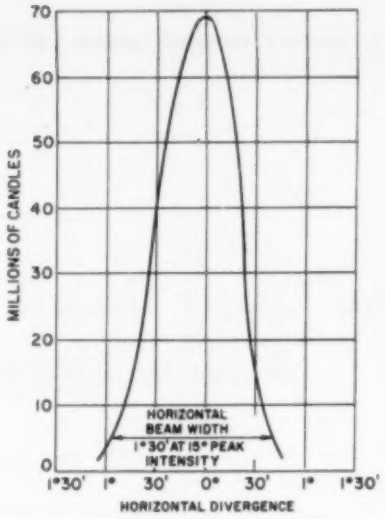


Figure 3. Photometric trace of the candlepower distribution of the 2500-watt short-arc lamp in 36-inch diameter semi-precision grade parabolic mirror.

obscure it from view at the lighthouse, the lighthouse beacon should be switched to the higher intensity operation to insure maximum possible visual range. This variable intensity feature has been used successfully in lighthouse operation at other locations.

Thus, a new step has been taken in an old field, where modern developments in the lighting industry have permitted an effective aid to maritime commerce.

1. Breckenridge, F. C.: "Fifty Years of Signal Lighting," ILLUMINATING ENGINEERING, Vol. LIII, No. 6 (June 1958).

I.E.S. Emblem

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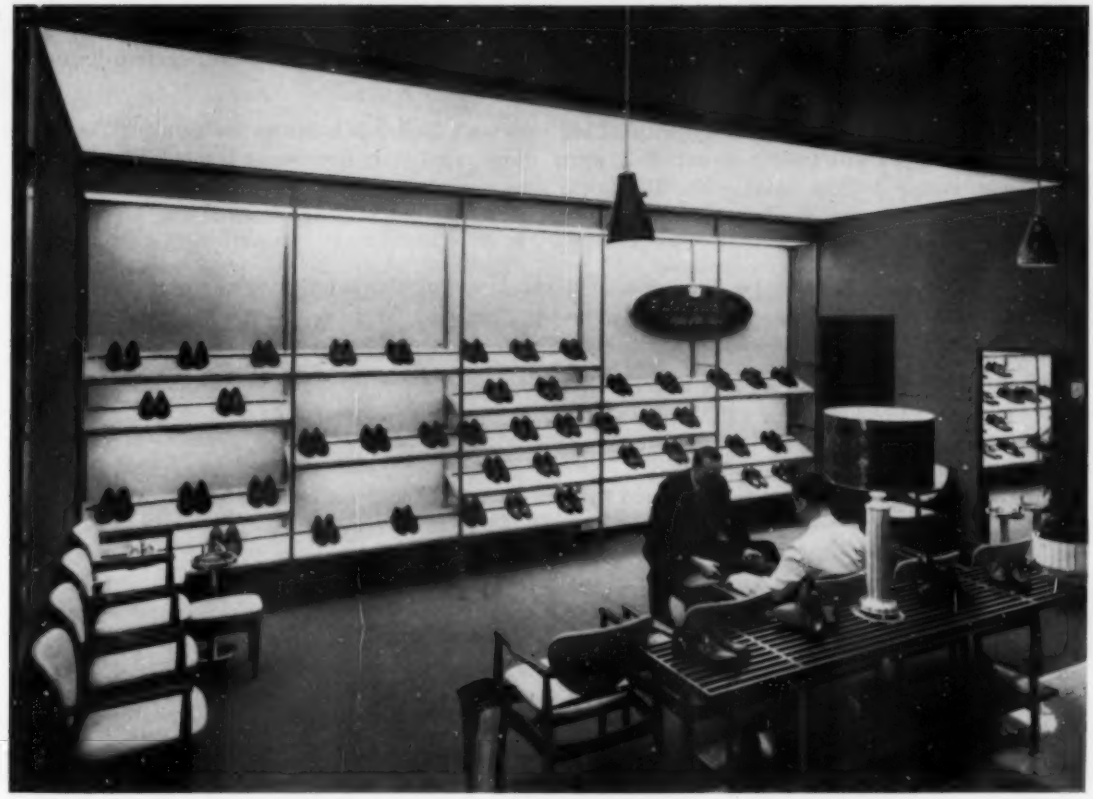

INSTALLATION AT ARTHUR FRANK STORE, SALT LAKE CITY, UTAH.

Lighting a Store's Shoe Department

LIGHTING OBJECTIVE: To provide a high level of general and display lighting in the men's shoe department of a clothing store to attract the store's customers and to facilitate shoe selection and sales.

GENERAL INFORMATION: The area which the shoe department occupies is 21 feet by 10 feet 6 inches. The luminous ceiling is 12 feet above the floor. The plenum above is 2 feet deep. Colors and reflectances of the major surfaces of the area shown in the photograph are as follows:

ceiling plenum	white	87% RF
side walls	brown	38% RF
back wall	light tan	53% RF
floor	rusty brown	7% RF
furniture	walnut	14% RF

INSTALLATION: General lighting is provided by the "Infinilite Ceiling" manufactured by Integrated Ceiling, Inc., Los An-

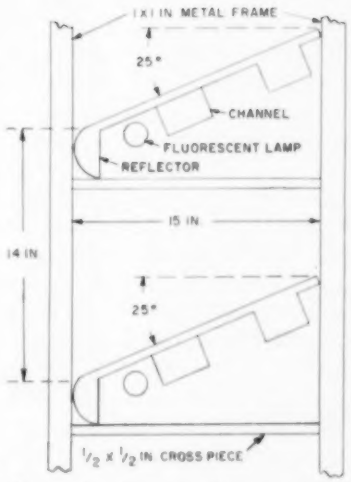

Figure 2. Cross section of custom made accent lighting units.

(over)

A.I.A. File No. 31

geles, Calif. There are ten 72-inch T-12 warm white fluorescent lamps (on 2-foot centers) and eight 150-watt inside frosted incandescent lamps (on 4-foot by 4-foot centers) surface mounted on the plenum ceiling above the "Infinilite" plastic louvers.

The soffit light over the top shelf of the back wall display is a custom built unit 20 feet long and equipped with twenty 40-watt T-12 warm white rapid start fluorescent lamps. The two pendant-mounted units, catalog No. 31024, are each equipped with one 150-watt incandescent lamp. Both the soffit and pendant units were manufactured by the Wagner-Woodruff Co., Los Angeles, Calif.

The accent lighting for the shelves of the back wall display is provided by custom made units, as shown in Fig. 2. These were designed by the Florsheim Shoe Co. and are equipped with continuous single rows of 40-watt T-12 warm white rapid start fluorescent lamps.

Illumination at shoe pedestal height is 115 footcandles; at three feet above the floor, 180 footcandles; and on the back wall display shelves, 240 (top) and 290 (others) footcandles. Brightnesses are as follows:

luminous ceiling	250 fL	floor	9 fL
side wall	15 fL	furniture	25 fL
back wall	50 fL		

Lighting designed by Harry Koepke, Florsheim Shoe Co., Chicago, Ill.; Architect: Burke, Kober and Nicolais, Los Angeles, Calif.; Electrical Contractor: Capitol Electric Co., Salt Lake City, Utah.

Lighting data submitted by J. Homer Shaw, Utah Power & Light Co., Salt Lake City, Utah.

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Economics of High Frequency Lighting

By R. D. BURNHAM

Benefits from the operation of fluorescent lamps at higher electrical frequencies have been previously discussed.[9, 10, 11, 12] By coordinating system design many of these factors may be reflected in terms of economic advantages. The information presented here is an attempt to outline some of the design opportunities and their economic implications, and to summarize in a general way the economic pattern with present day systems.

Some high frequency fluorescent lighting systems of today have the same appearance and flexibility as their 60-cycle counterparts. Any of the standard fluorescent lamps can be employed; preheat, instant start, and rapid start ballast circuits are used and other improved circuits are made possible because of the higher frequency.

In order to study the comparative economics between two lighting systems of different frequencies, it is necessary to incorporate each lighting system in turn in the overall electrical design of the building; then determine accurately the total cost of the electrical contract providing the same electrical function in each case. The cost difference may then be significant, but only for the conditions imposed. In some cases this procedure must be extended to the heating and ventilating contract and occasionally include differences in building structural cost.

Potential savings or costs due to change in frequency are often quite remote from the lighting equipment itself. For example, savings may occur in substation transformer size, secondary switchgear, and electrical distribution feeders for air conditioning and lighting. Cost additions may stem from an increased number of lighting panels, a double distribution system, 60-cycle and high frequency, and additional wiring for frequency changer controls. Superficial economic studies are of limited value and are sometimes misleading. Complete analysis, in order to determine economic conditions accurately, becomes rather complex and can usually not be justified for each installation under consideration. Summary data of several studies of this general nature are grouped in Table III in the hope that a significant trend might be indicated.

High frequency system design should take advantage of the improved fluorescent lamp operating characteristics at higher frequencies and reflect either an economic or a performance improvement for each trait of advantage. The application engineer adapting a system of this nature to a specific area is charged with adjusting performance and cost to best suit the users' needs. His ingenuity, design skill and complete understanding of the potentials of the high frequency system can greatly influence the resulting economic conditions.

Author: Hi-Frequency Systems, Inc., Vermilion, Ohio.

Frequency Conversion

The key to the economic feasibility of high frequency lighting at the present time rests largely in the cost and performance characteristics of the frequency changing equipment. To evaluate these economic aspects as well as the "state of the art," a survey was made of 104 consulting engineers, research groups and manufacturing companies who specialize in the design and/or manufacture of frequency changing equipment of all types. An analysis of results showed an almost unanimous opinion that the rotary type frequency changer provides excellent performance and a significant economic advantage over other types. This was again confirmed by each of four development groups working independently studying the overall technical and economic aspects of high frequency lighting systems.

There are at least two major static frequency changer types now in use. The harmonic type frequency changer was one of the first types to be used for specialized lighting applications. Several groups are working on technical improvements and units with larger electrical capacities are being designed and tested. The electronic frequency changer using either power transistors or controlled rectifiers are being seriously investigated.[14] The recent development of these solid state control components suggests the possibility of interesting

TABLE I — Rotary High Frequency Systems.

Type	Frequency Nominal	Voltage Nominal	Distribution
Salient Pole	420	600	3 — single phases
Permanent Magnet	840	600	3 — single phases
Permanent Magnet	840	277/480	3 phase, 4 wire

Type	Unit Capacity	Lamps	Ballast	Switches and Circuit Breakers
	KVA			
Salient Pole	25, 50, 100	Slimline Power Groove	Split Phase	2 pole, 600 V
Permanent Magnet	30, 60	Slimline	Capacitance and auxiliary power factor correction	2 pole, 600 V
Permanent Magnet	16, 30, 60	Any	Modified Capacitance	1 pole, 277 V

future developments in static frequency changers. Men working on the development of these solid state devices express the belief that it will be several years before the present technical barriers are overcome and possibly a longer time before the cost and reliability of these units can approach that of rotary equipment. Units of this type are available today from several sources and may find use in specialized areas where cost is not of prime importance and where physical or particular performance characteristics of these units are desirable.

Since rotary equipment has been used in nearly all installations of significant size up to the present time, attention is focused on this method of frequency conversion for the purpose of economic analysis. Table I outlines the three primary systems currently using rotary frequency changing equipment. All three of these systems have been used in full scale installations so field data are known for each type.

Design Opportunities for Economy

Two basic distribution methods may be used with rotary equipment. The first is the automatic central system. This consists of two or more frequency changers which automatically sense the load requirements, start and parallel additional frequency changers as the lighting load increases. Frequency changers are disconnected in a similar manner when the load decreases. This method takes advantage of the economy of larger frequency changing equipment and can be made completely automatic.

Since this equipment is in one location, effective sound insulation can easily be provided to prevent noise transfer to occupied areas. The central system usually lends itself to use in larger installations where the added cost of paralleling and control equipment can be justified or offset by the lower cost of frequency changing equipment in larger capacities.

The second system and one most widely used at the present time is the block or area system. One of two frequency changers are used to supply the power to lighting in a specific area. Additional frequency changers supply other areas in a similar manner. Switching for the area may be provided either by a push button energizing the magnetic motor starter, switch from the lighting panel or local switching by means of toggle switches. It is often advisable to circuit the area so that a nominal lighting level in any area will be maintained with any one of the frequency changers off the line. Installations have been made utilizing a single frequency changer. This is usually recommended only where the specific job conditions warrant and the highest degree of reliability is not essential.

In general, the larger the frequency changer capacity, the lower the cost per kva for frequency conversion. This does not seem to hold as true for the permanent magnet type frequency changers. This trait makes it practical to use two 16-kva frequency changers in place of one 30-kva which gives greater reliability and flexibility with only a ten per cent increase in cost of the frequency changing equipment. This makes high frequency lighting practical for some installations where the total lighting load is only 15 to 30 kilowatts.

Electrical Distribution

The electrical distribution is usually either a 600-volt, single phase, six-wire system or a 277/480-volt, three-phase, four-wire system. The number of lighting branch circuits to provide a given illumination is often reduced from 25 to 30 per cent due to the lower ballast losses and higher lamp efficiency. The higher voltage lighting circuits sometimes further reduce the number of branch circuits. Wiring costs can be reduced especially where long circuit runs are involved such as with high bay industrial areas, gymnasiums and aircraft hangars. Standard wire and conduits can gener-

TABLE II — Typical Dispersement of Cost Differences.

Cost difference for 277/480 V, 840-cycle compared with 120/208 V, 60-cycle

Equal Illumination	Cents Per Watt Additional Savings
A. Frequency changer with magnetic motor starter	13
B. Difference in ballast cost	6
C. Difference in wiring cost	5
D. Difference in air conditioning cost	6
E. Difference in fixture cost installed with high frequency lamp output increased 33%. Number of fixtures reduced proportionally	11

Figure 1. 840-cycle, rapid-start lighting system at the Saxon Bowling Lanes, Salem, Ohio. Architects: Bergemann and Smith, Alliance, Ohio.

ally be used for lighting branch circuits. Information on line losses, feeder calculations and overcurrent protection is available for each system from the system supplier.

Luminaires

Some of the main advantages of high frequency lighting are manifested in the luminaires. Ballast circuits are usually designed to provide good lamp performance in a range where the cost of light is the best interest of the user. When fluorescent lamps are operated at higher frequencies, it is practical to increase lamp wattage and light output. It is general practice to increase the light output per lamp from 20 to 35 per cent, depending on the lamp and system, in order to provide light at the most economical level. Even with the higher wattage, lamp performance is good and often better than the rated operating conditions at 60 cycles.

The increased light output per lamp makes it possible to increase the illumination proportionally with the same fixture placement or reduce the number of fixtures and decrease the initial cost of lighting equipment. The latter technique often makes it possible to use the minimum spacing for good uniformity and select lamp brightness for the desired illumination level. This simplifies installation, wiring, and lighting maintenance.

At frequencies above 300 cycles, it is practical to utilize the capacitor as a current limiting device for the fluorescent lamp. This tends to decrease the size, weight, and cost of fluorescent lamp ballast. The size and weight of inductances are also decreased at elevated frequencies. Therefore, wheth-

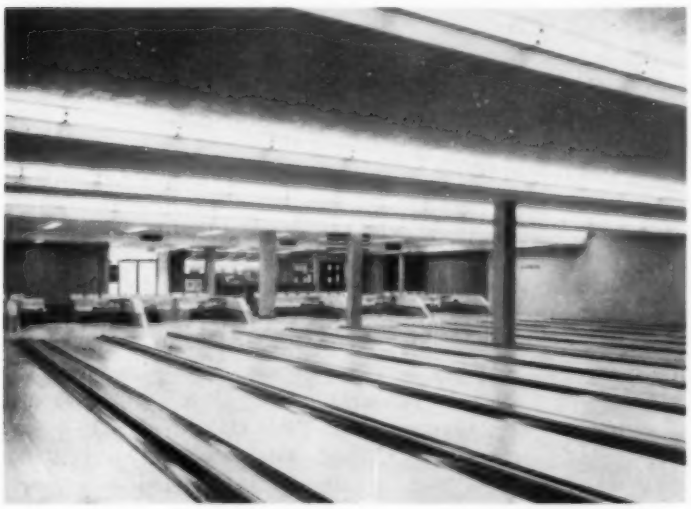


Figure 2. Saxon Bowling Lanes using four-foot rapid-start lamps operating from an 840-cycle, three-phase, four-wire distribution system. Lumen output per lamp is increased 26 per cent.

TABLE III — Typical Cost Comparison.

Type of Area	60-CYCLE CONDITIONS		HIGH FREQUENCY CONDITIONS			
	Voltage	Lamps	Frequency	Voltage	Lamps	Electrical Load
Industrial	277/480	Slimline	420	600	Slimline	25 kw
Industrial	277/480	Slimline	420	600	Slimline	100 kw
Industrial	277/480	Power Groove	420	600	Power Groove	25 kw
Industrial	277/480	Power Groove	420	600	Power Groove	100 kw
Industrial	277/480	Slimline	420	600	Slimline	200 kw
Field House	120/208	Mercury-Incandescent	420	600	Slimline	100 kw
Industrial	277/480	Power Groove and High Output Rapid-Start	840	277/480	Power Groove and High Output Rapid-Start	235 kw
Industrial	277/480	Power Groove and High Output Rapid-Start	840	277/480	Power Groove and High Output Rapid-Start	150 kw
Bowling Alley	120/208	4-Foot Rapid-Start	840	210/365	4-Foot Rapid-Start	30 kw
Industrial and Office	120/240	High Output Rapid-Start 4-Foot Rapid-Start	840	277/480	High Output Rapid-Start 4-Foot Rapid-Start	90 kw
Industrial and Office	277/480	High Output Rapid-Start 4-Foot Rapid-Start	840	277/480	High Output Rapid-Start 4-Foot Rapid-Start	90 kw
Industrial and Office	120/208	Power Groove and 4-Foot Rapid-Start	840	277/480	Power Groove and 4-Foot Rapid-Start	30 kw
Office	120/208	4-Foot Rapid-Start	840	210/365	4-Foot Rapid-Start	375 kw

PERCENTAGE COST DIFFERENCE FOR HIGH FREQUENCY

Type of Area	Initial	Operation	Power Cost per kwh	Reference
Industrial	− 4	+ 7	2¢	1
Industrial	−15	+ 1	1¢	1
Industrial	+ 6	+ 3	2¢	1
Industrial	−11	+ 2	1¢	1
Industrial	−16	− 1	1¢	2
Field House	− 6	−24	1¢	3
Industrial	− 5	−13	1¢	4
Industrial	−13	−19	1¢	4
Bowling Alley	− 7	−13	2¢	5
Industrial and Office	−11	−14	1¢	6
Industrial and Office	− 5	−16	1¢	6
Industrial and Office	+ 3	−21	1¢	7
Office	−15	−14	2¢	8

er the circuit is capacitive or a combination of inductance and capacitance, size, weight, and cost are usually less. This reduced ballast cost decreases the lighting fixture cost. Since fewer fixtures may be required and each fixture costs less, the total fixture cost is often substantially reduced.

Air Conditioning

As previously mentioned, the wattage supplied to the lighting fixtures is often reduced from 25 to 30 per cent due to increased ballast and lamp efficiency. In many air-conditioned areas this is a significant factor in determining the initial air conditioning capacity.[13] The total heat generated within the air-conditioned area from the lighting system and other sources determines the air conditioning capacity and cost. Accurate cost can only be determined for specific job conditions because of wide variations in other heat loads. As an example, a one-story building with a high solar load may show a very small change in air-conditioning capacity due to the reduced lighting load since the heat developed by the lighting system is a small percentage of the total heat to be ejected. On the other hand, in a multi-story building where the heat load due to lighting is a large per cent of the total heat generated, the savings may be many thousands of dollars due to the reduction in the total fixture wattage.

Operation and Maintenance

If lamps are operated on high frequency circuits at rated lamp currents, lamp efficiency and lamp life may be expected to increase for nearly all lamps. If the lamps are more heavily loaded to reach a more beneficial economic range, lamp efficiency and lamp life are reduced slightly approaching the 60-cycle conditions. Lamp life for installations which have been in service for several years show a very favorable record. Lamp life mortality curves seem to be more perfect in shape. The tendency seems to be for all lamps to burn out more nearly at the same time. This characteristic makes installations of this type good candidates for group lamp replacement schedules. The rated lamp life may be longer and the effective lamp life for group replacing may be longer because fewer lamps burn out prematurely. This combination may be a means of reducing lamp replacement costs.

Very little statistical data on ballast life is yet available. Due to the inherent design of most of these ballast circuits, operating temperatures are considerably below those incurred on 60-cycle ballasts. It is, therefore, expected that the life of high frequency ballasts will be as good and with some ballast types, better than the current 60-cycle units.

Some high frequency systems have an overall efficiency approximately the same as a comparable 60-cycle system. Others can show a definite savings in power costs (see Table III). Where the overall efficiency is high, the total connected 60-cycle electrical load is reduced. This sometimes effects a

Figure 3. Frequency conversion and remote control switching equipment for bowling lane installation shown in Figs. 1 and 2.

reduction in electrical demand as well as the kilowatt hour power usage. In areas where electrical costs are determined on demand and kilowatt hours, the actual reduction in electrical power cost may be greater than that indicated and calculated solely on a kilowatt hour basis.

In air-conditioned areas, the operational cost is reduced since the additional heat generated by the lighting system need not be continually pumped out of the area throughout the life of the system.

The frequency changer is an additional source of maintenance. Rotary frequency changers for the systems mentioned have been designed for continuous duty and a high degree of reliability. They have been designed specifically for this application in order to minimize maintenance as much as possible. An inspection of the frequency changing equipment is usually recommended each six months. Lubrication is necessary on a one- or two-year interval. A general cleaning and overhauling may be required every eight to ten years.

General Economics

Using the systems considered, an electrical load of 30 kilowatts is usually required before it becomes practical to consider high frequency for general lighting purposes. Table III shows typical comparative costs for several high frequency applications. These data are selected to give a general picture of initial and operating costs for various conditions. These figures are believed to be fairly representative and have good correlation with many other studies of a similar nature. Each area to be lighted has its own restrictions to be imposed and opportunities to be explored. Reviewing the data in Table III, it appears that some savings may be made initially with the use of high frequency lighting for some areas. An increased initial cost is apparent in a few instances; but, in general, a saving from 5 to 15 per cent seems typical. It does not seem significant whether the system is 420 or 840 cycles fr the standpoint of initial cost. The 420-cy ency changing equipment is generally than the 840-cycle units. The balla al distribution may be slightly les 0-cycle system which tends to offse y changer cost difference.

It also seems app hese data that the larger the electrical l e greater the initial savings. The extent of the initial savings depends to a considerable degree on the type of application and the specific job conditions as well as the ability of the electrical designer to utilize the inherent potentials of each system selected with respect to the given installation.

The overall efficiency of the 420-cycle system is approximately the same as a comparable 60-cycle fluorescent system. The 840-cycle rapid start system has a reduced ballast loss and higher lamp efficiency. It, therefore, shows a savings in cost of operation reflected mainly from the reduction in the electrical power consumed. This savings in operation is, in many cases, a prime reason for the use of high frequency lighting. An example of this may be pointed out in the following analysis.

Typical Comparison

As a specific example, an industrial area is studied in greater detail. The larger section is a storage and receiving area to be illuminated to approximately 25 footcandles. The factory area is to be illuminated to 50 footcandles. The 277/480-volt, three-phase, four-wire, 840-cycle system is selected after making preliminary cost studies for all systems. The 16-kva frequency changer was selected to give area type lighting control. Area switching is accomplished by means of a push button energizing the motor starter. Continuously lighted emergency circuits are provided throughout both areas. One 16-kva stand-by frequency changer is provided and located so that it can be put into service in place of any other unit as re-

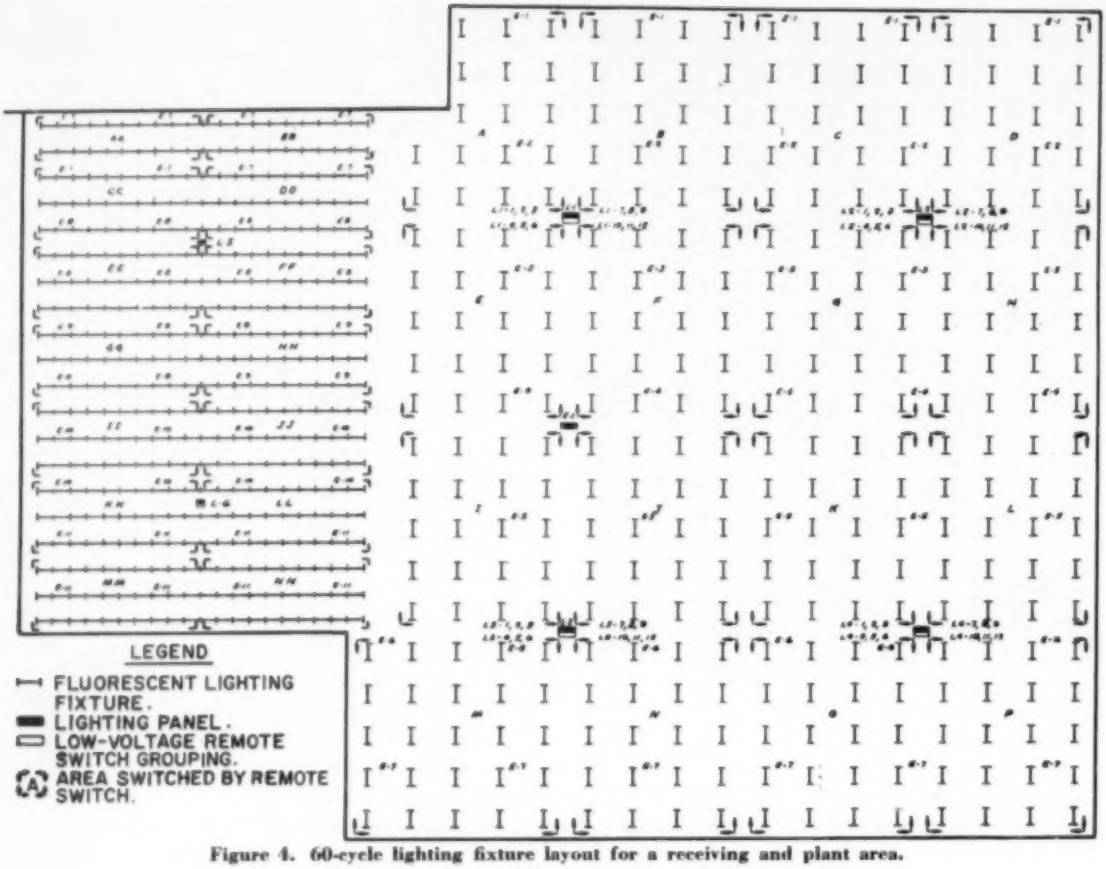


Figure 4. 60-cycle lighting fixture layout for a receiving and plant area.

quired. A general comparison of characteristics is given in Table IV.

The illumination is nearly the same for either arrangement. The number of fixtures is reduced for the high frequency layout by operating the lamps at a high lamp brightness. The connected electrical load is reduced 9 per cent. The lighting wattage density is reduced 23 per cent. Fixture weight is reduced 37 and 31 per cent. Reduction in fixture weight has a slight effect on installation cost particularly at higher mounting heights.

Comparative cost of two installations is given in Table V. An initial savings of 4.8 per cent is indicated with the 840-cycle system. An alternate is

TABLE IV — System Comparison.

	60-Cycle	840-Cycle
Illumination in Service		
Receiving storage area	24.6 fc	23.5 fc
Plant area	51.0 fc	51.6 fc
Number of Fixtures		
Receiving storage area	322	257
Plant area	400	324
Wattage		
Total 60-cycle connected load	259 kw	235 kw
Total branch circuit loading	259 kw	200 kw
Power Groove 2-lamp fixture watts	475	460
High output 2-lamp fixture watts	264	253
Lamp Lumens		
8-foot Power Groove	13,000	15,600
8-foot high output	7,300	9,100
Lamp Current		
Power Groove	1.5	1.9
High output	.8	1.0
Fixture Weight		
2-lamp 8-foot Power Groove	57	36
2-lamp 8-foot high output	51	35

TABLE V — Relative Initial Cost.[1]

	60-Cycle 277/480-Volt	840-Cycle 277/480-Volt Condition A[2]	840-Cycle 277/480-Volt Condition B[3]
Lighting fixtures installed	66.0	40.0	40.0
Lamps installed	9.5	7.7	7.7
Lighting panels installed	4.0	—	—
Starters or remote switches installed	4.4	2.7	1.6
Frequency changers installed	—	32.1	20.8
Feeders installed	7.3	5.9	9.5
Branch circuits installed	8.8	6.8	7.2
	100.0	95.2	86.8

1. All figures are given as a percentage of the total lighting contract for the 60-cycle installation.
2. Full high frequency electrical capacity with one spare stand-by unit.
3. Frequency changing equipment reduced to ⅓ full capacity in receiving area interconnected so that any bay could be lighted, but not more than 3 bays at one time. One spare stand-by unit provided.

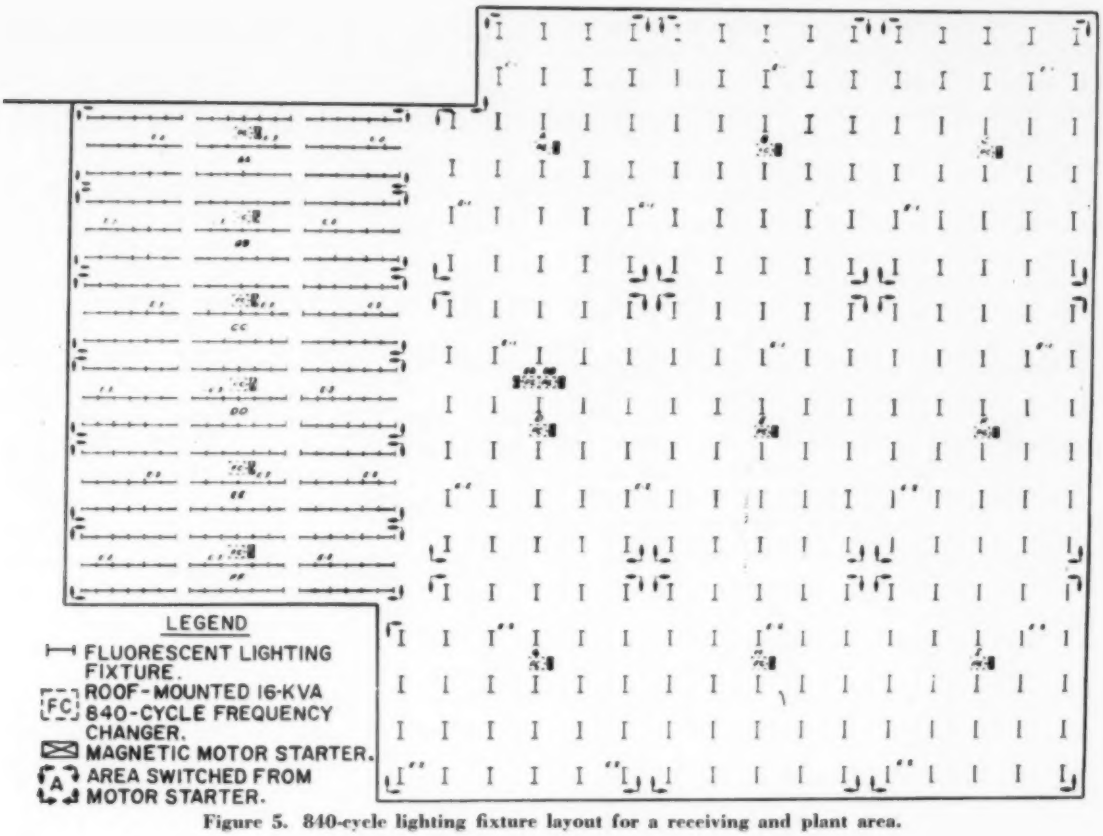


Figure 5. 840-cycle lighting fixture layout for a receiving and plant area.

provided reducing the frequency changing capacity in the receiving-storage area. The use of this area may be such that only two or three of these bays would be fully lighted at any one time. By adjusting circuitry for better utilization of equipment, original installed cost may be further reduced.

Table VI indicates the probable savings in cost of operation of the high frequency system. If the lighting system were operated according to the assumptions indicated, a 13 per cent reduction in the cost of operation is estimated. This example indicates a moderate savings in initial cost and a probable savings in operation cost.

TABLE VI — Cost of Operation per Year.

	60-Cycle 277/480-Volt	840-Cycle 277/480-Volt	Cost Difference
Power cost at 1¢ per kwh—2860 hour/year	7400	6700	−700
Group lamp replacement and fixtures cleaned ..	1360	790	−570
Ballast replacement per year	341	36	−305
Frequency changer maintenance	—	400	+400
Operational savings per year with 840 cycles			$ 1,175
Total estimated operational savings for an assumed life of 20 years			$23,500

Summary

During the last few years high frequency lighting technology has progressed rapidly. Today, design flexibility and latitude is as great and in some cases greater than with conventional systems. Limited statistical data indicate the possibility of reducing the initial cost of fluorescent lighting systems in some cases from 5 to 15 per cent. Cost of operation seems to be a significant advantage of the 840-cycle, 277/480-volt, three-phase, four-wire system.

Reduction in operating costs between 10 to 20 per cent is possible for some installations.

Although the use of high frequency lighting does not seem to be advantageous for the majority of lighting installations, it appears to have merit for certain types and sizes of fluorescent lighting installations where the combination of job conditions is such that the inherent advantages of operating fluorescent lamps at higher frequencies may be utilized to best advantage. High frequency seems particularly well suited for the 800- and 1500-ma rapid start lamps since ballast weight, heat and cost advantages become most predominant.

The economic limit is not yet reached with present high frequency systems. System efficiencies can be increased another 10 to 20 per cent through refinements in design which would reduce operating costs accordingly. High frequency components are in limited production. Mass production methods would probably reduce equipment costs substantially and very little consideration has yet been given to the possibility of miniaturizing lighting fixtures now possible because of smaller ballasts. This may tend to further reduce fixture cost and possibly improve fixture efficiency. These yet undeveloped aspects may further enhance high frequency lighting economies in the future.

References

1. Dobras, Q. D.: "High Frequency Lighting Summary," General Electric Lamp Division, Application Engineering, Industrial Lighting Division (June 17, 1958, revised November 5, 1958).
2. Campbell, J. H., Dobras, Q. D.: "Development and Application of High Frequency Fluorescent Lighting," a paper presented at A.I.E.E. Winter General Meeting, New York, New York (January 21-25, 1957).
3. Bulletin G.E.A. — 6559, "General Electric High Frequency for Fluorescent Lighting Systems," General Electric Lamp Division, Nela Park, Cleveland, Ohio.
4. Interoffice Engineering Bulletin, "Project Report 105A," Hi-Frequency Systems, Incorporated, Vermilion, Ohio (January 1959).
5. Interoffice Engineering Bulletin, "Project Report 96," Hi-Frequency Systems, Incorporated, Vermilion, Ohio (October 1958).
6. Burnham, R. D.: "High Frequency Lighting Proves Means of Stretching Construction Dollar," *Electrical South* (October 1958).
7. Interoffice Engineering Bulletin, "Project Report 108A," Hi-Frequency Systems, Incorporated, Vermilion, Ohio (January 1959).
8. Interoffice Engineering Bulletin, "Project Report 109," Hi-Frequency Systems, Incorporated, Vermilion, Ohio (February 1959).
9. Spencer D. E.: "Frequency and Fluorescent Lamps," *Electrical Engineering*, Vol. 72, No. 12, pp. 1066-70 (December 1953).
10. Campbell, J. H., Schultz, H. E., Kershaw, D. D.: "Characteristics in Applications of High Frequency Fluorescent Lighting," ILLUMINATING ENGINEERING, Vol. XLVIII, No. 2, page 95 (February 1953).
11. Burnham, R. D.: "840-Cycle Fluorescent Lighting," a paper presented at the A.I.E.E. Winter General Meeting, New York, New York (January 21-25, 1957).
12. Burnham, R. D.: "High Frequency Lighting," *Architectural Record*, Vol. 122, No. 26, page 193-195 (December 1957).
13. Bogen, S. A.: "The Economic Lighting Limit," ILLUMINATING ENGINEERING, Vol. XLV, No. 8, page 503 (August 1950).
14. Johnson, W. H., Winpisinger, J. L., Roesel, J. F., Jr.: "A New High Frequency Power Source for Fluorescent Lighting," ILLUMINATING ENGINEERING, Vol. LIV, No. 1, page 43-50 (January 1959).
15. Myers, G. A., Strojny, F. M. W.: "Design of Fluorescent Lamps for High Frequency Service," ILLUMINATING ENGINEERING, Vol. LIV, No. 1, page 65-70 (January 1959).

Jet-Age Lighting for a Ticket Office

Illumination level is 90 footcandles in this ticket office at Continental Air Lines. Single-lamp fluorescent strips with reflectors are mounted above the one-inch-square aluminum louvers, which are painted white. In the area at left in the photograph, are 150-watt downlights mounted on 5-foot centers. Walls are bright blue, 24% RF; walnut, 10% RF and pale yellow, 50% RF. Floor has gold carpeting, 50% RF, and white and brown, 50% RF. Architect and engineer was George L. Dahl. Photo courtesy Dallas Power & Light Co.

Experiences with

High-Frequency Fluorescent for Experimental Plant Growth Chambers

PLANT scientists, continually looking for certain desirable characteristics in plants, make use of controlled "plant growth chambers" where several generations of plants can be produced per year. In some cases it may take as many as ten generations of plants to breed, to a dependable degree, such desirable characteristics as resistance to disease, higher yields, and more efficient conversion. Environmental chambers, where such factors as light, temperature and humidity can be controlled, can speed up the cyclic processes in plant production.

In the autumn of 1956, two scientists in the Botany Department of Clemson College requested the Agricultural Engineering Department to design lighting and air-conditioning installations for two such environmental chambers. Each of the two insulated rooms is 6 by 9 feet in area with an 8-foot ceiling. Levels of illumination specified were 2000 footcandles, with some provision for dimming. Temperature range was to be 30 to 130 F.

Previous experiments, including those at Beltsville, Md.,[1] had shown the effectiveness of high-frequency fluorescent sources for such applications. This was the system decided upon, using a static frequency multiplier to change the 60-cycle, three-phase power supply to 360-cycle single-phase, with an increase in voltage and a conversion from sine to square wave.

The frequency multiplier is mounted outside the air-conditioned chambers, with two wires supplying the power for the 40 fluorescent lamps in each chamber. The two-lamp ballasts, which weigh less than one pound, are mounted inside the chamber, since their low power loss creates little heat load.

Another useful feature of the high-frequency system is the incorporation of an output current control on the multiplier, which permits a variation in illumination level. Levels for this installation can be varied from a maximum of 2000 footcandles to a minimum of 1400, sufficient for growth of most plants. This variation is accomplished over a temperature range of 30 F to 130 F. Desired temperature is maintained with refrigerating and heating equipment. The refrigerating equipment consists of a 5 HP condensing unit with properly matched evaporating equipment, and the heating unit consists of a steam coil. These heating and cooling units are operated concurrently by an electronically controlled thermostat.

Standard warm white lamps are used, mounted on 1¾-inch centers at a height of four feet above the tables. Controls for each room are located on separate panels outside the room. All electric power is metered so that operational data may be evaluated.

Installation designed by Carl J. Turner, Assistant Agricultural Engineer, The South Carolina Agricultural Experiment Station, Clemson, S. C., and Ernest B. Rogers, Jr., Associate Professor of Agricultural Engineering, The Clemson Agricultural College, Clemson, S. C.

1. United States Department of Agriculture, Beltsville, Md., installation, reported on in "Report of the IES Committee on Progress, 1950-1951," ILLUMINATING ENGINEERING, Vol. XLVII, No. 1 (January 1952). See also, Dobras, Q. D.: "Applications of High-Frequency Fluorescent Lighting," ILLUMINATING ENGINEERING, Vol. LII, No. 7 (July 1957).

Recommended Levels,

Interior and Exterior

	Currently Recommended Illumination* Footcandles
BANKS	
Lobby	
General	50
Writing areas	70
Tellers' stations	150
Posting and keypunch	150
Regular office work	100
CHURCHES and SYNAGOGUES	
Altar, ark, reredos	100**
Choir*** and chancel	30**
Classrooms	30
Pulpit, rostrum (supplementary illumination)	50**
Main worship area***	
Light and medium interior finishes	15**
For churches with special zeal	30***
GYMNASIUMS	
Exhibitions, matches	30
General exercising and recreation	20
Assemblies	10
Dances	5
Lockers and shower rooms	10
HOSPITALS (Nurses' station)	
General	20
Desk and charts	50
POST OFFICES	
Lobby, on tables	30
Sorting, mailing, etc.	100
RESTAURANTS, LUNCH ROOMS, CAFETERIAS	
Dining areas	
Cashier	50
Intimate type	
Light environment	10
Subdued environment	3
For cleaning	20
Leisure type	
Light environment	30
Subdued environment	15
Quick service type	
Bright surroundings†	100
Normal surroundings†	50

SERVICE STATIONS (at grade)

	Dark Surroundings	Light Surroundings
Approach	1.5	3
Driveway	1.5	5
Pump island area	20	30
Building faces (exclusive of glass)	10††	30††
Service areas	3	7

SHOW WINDOWS	
Daytime lighting	
General	100
Feature	1000
Nighttime lighting	
Main business district, highly competitive	
General	200
Feature	1000
Secondary business districts or small towns	
General	100
Feature	500
TESTING	
General	50
Extra-fine instruments, scales, etc.	200‡

During remodeling of this small-town bank, the 11-foot ceiling was dropped to 8 feet with a corrugated plastic luminous ceiling. The 3-foot-deep plenum was painted with 80 per cent reflectance white. Single-lamp strip, with 40-watt rapid-start lamps, provides 100 footcandles average in the general banking area. Walls are 50 per cent reflectance; floors are 20 per cent and work surfaces are from 50 to 60 per cent reflectance. (A)

Notes

* Minimum on the task at any time.

** Two-thirds this value if interior finishes are dark (less than 10 per cent reflectance to avoid high brightness ratios, such as between hymnbook pages and the surround. Careful brightness planning is essential for good design.

*** Reduced or dimmed during sermon, prelude or meditation.

† Including street and nearby establishments.

†† Vertical.

‡ Obtained with a combination of general lighting plus specialized supplementary lighting. Care should be taken to keep within the recommended brightness ratios. These seeing tasks generally involve the discrimination of fine detail for long periods of time under conditions of poor contrast. To provide the required illumination, a combination of the general lighting indicated plus specialized supplementary lighting is necessary. The design and installation of the combination system must provide not only a sufficient amount of light, but also the proper direction of light, diffusion and eye protection. As far as possible it should eliminate direct and reflected glare as well as objectionable shadows.

Pump island units in this gasoline station each have six 72-watt T12 high-output lamps for levels of about 35 footcandles. Area lighting fixtures supply 6 footcandles in the yard, using four 48-watt extra-high-output lamps. (B)

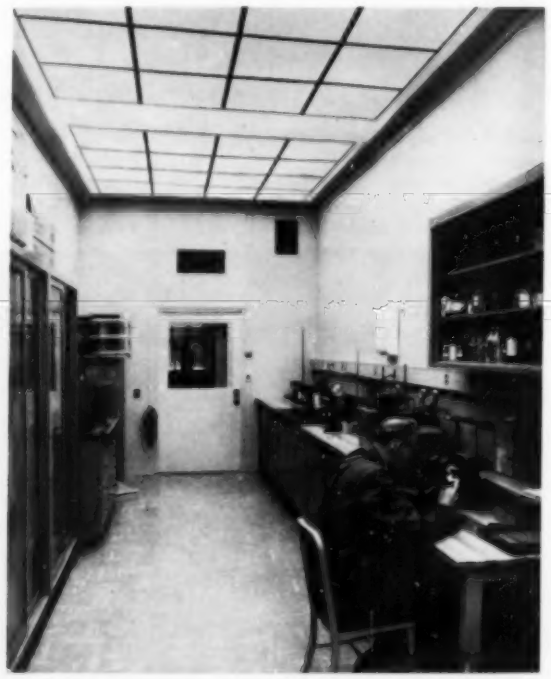
FROM banks to service stations—indoors and outdoors—lighting installations which meet current IES recommendations are confirming in practice what scientific research has advocated. Some of these installations, in industry, offices and schools, were featured in the June issue of ILLUMINATING ENGINEERING: others, a more diverse assortment, are shown here: stores and merchandising areas, which have their own particular problems, will be illustrated in the August issue of IE. Credits for photographs on these pages, keyed to the letter at the end of each caption, appear on page 432.

One large showroom and one small area with a revolving turntable for one car have lighting levels of 115 and 230 footcandles respectively. In the large showroom, general lighting is by eleven 8-foot slimline fixtures each with four 96-inch T12 cool white lamps and 45-degree shielding, supplemented by sixteen 150-watt incandescent units following the contour of the wood-paneled wall. Window lighting is from twenty-three hood-type fixtures with 150-watt R40 spots mounted on the ceiling. The small showroom turntable area is highlighted by thirty recessed fixtures with 150-watt R40 lamps in two concentric circles above the table. Window lighting here is also by hood-type fixtures. (C)

Initial level was 50 footcandles on the play area of this high school gymnasium. Etched and anodized aluminum fixtures with double-walled parabolic baffles and an individual parabolic reflector for each lamp are hung on chains for easy servicing and to let them ride with the blows received from balls and other objects in their normal use. Lamps are extra-high-output. (D)

Continuous rows of louvered luminaires, mounted one foot from the 11-foot-high ceiling, supply 280 footcandles in a research laboratory. Each unit uses two extra-high-output lamps. (E)

Levels up to 120 footcandles are supplied on the gasoline pump islands with 40-foot long, 10-foot high fixtures, using extra-high-output lamps. Units are composed of two rows of 8-foot luminaires. An air gap between the luminaires and the aluminum structural member above provides for cooling. (F)



Two "floating panel" luminaires, using 96-inch T12 cool white lamps, one foot on centers, provide 110 footcandles in another laboratory. (G)

Average illumination in this 1565-square-foot coffee shop (right) is about 50 footcandles, from thirteen 8-foot and seven 4-foot recessed troffers with light opal glass panel diffusers, and fourteen 150-watt R40 recessed spots. Each troffer uses three warm white deluxe lamps. Room surfaces are: floor, light tan; walls, coral and cocoa; ceiling, off-white. (H)

Two-lamp strip, four feet on centers, with 30-watt T12 warm white lamps is mounted over a louvered ceiling at a nurse's station in a hospital. Average level of illumination is 35 footcandles with 120 on the rear desk. (I)

Indirect incandescent units, in keeping with the decor, provide 15 footcandles in the pew area of this church. Concealed directional units light the altar area. (J)

Illumination levels meeting IES recommendations are provided in this bank by a luminous ceiling of corrugated Plexiglas. Above the plastic are nearly 1000 4-foot rapid-start lamps in continuous rows on 18-inch centers. (K)

General illumination for the pews is from recessed incandescent downlights. Garden area, visible through the glass walls, is floodlighted at night. (L)

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(N), (O) and (P) San Diego Gas & Electric Co., San Diego, Calif.
(Q) General Electric Co., Cleveland, Ohio.

Recessed louvered troffers, with 40-watt T12 warm white deluxe lamps, provide 70 footcandles at table level. (M)

Light-colored surfaces for floor, walls, counters and desks add to the environment where 120 footcandles are provided from continuous rows of ceiling-mounted luminaires with plastic shielding. (N)

Mail sorting is made easier under 100 footcandles on the task. Light-colored floor, walls and equipment contribute to the seeing environment. (O)

General illumination of 125 footcandles prevails in this automobile display room, with ceiling-mounted louvered luminaires. Featured car behind the curved glass wall is highlighted to 270 footcandles. Spotlights are arranged in groups of five around the perimeter of the room. (P)

Flexibility, in a large restaurant area which can be sub-divided by partitions, is obtained by dimmer control of the 40-watt T12 cool white deluxe lamps in plastic panels and colored R40 lamps in recessed downlights. (Q)

A New Simple Approach to

Group Relamping of Fluorescent Lamps

By E. W. BEGGS

Introduction

The mortality data on current product fluorescent lamps show that revolutionary changes have taken place in the last few years. Lamp life is more uniform and so few lamps burn out early in life that old curves and old relamping systems are obsolete. Today most installations should be relamped when 5 per cent or less of the lamps have burned out. In practically all industrial systems and many other lighting systems, this completely eliminates the nuisance of spot relamping and reduces lighting maintenance to a new low cost.

The new mortality curve is more square in shape and drops more steeply than the old. It permits relamping later in life with relatively few failures, giving the user the maximum economic use of the lamps. It shows also that group relamping before the knee of the curve is reached is now a necessity in order to prevent excessive outages in the lighting system during the period of high lamp mortality.

Studies of actual operations show that group relamping is generally done when luminaires are washed. The relamping time is set so as to coincide with the washing program resulting in little or no cost for relamping labor. They also show that for most installations the preferred schedule is to group relamp every two years.

To simplify discussion, only mechanics and the direct costs of random *vs.* group relamping systems are analyzed. Higher maintained levels of lighting are also obtained with group relamping, and the inconvenience of work interruptions is largely eliminated. While no costs or values are given for them, these two important extra advantages are provided to those who group relamp and especially to those who relamp early.

Life Expectancy of Fluorescent Lamps

The mortality curve for fluorescent lamps reveals the life expectancy of individual lamps in a group. With lamps, as with any other product, no two are exactly alike, nor will their lives be exactly the same. This is because of inevitable variations in the product. In addition to variations in the lamps, there are also variations in the operating conditions to which each lamp is subjected so that it has always been assumed, and properly so, that with any installation of new lamps there will be very few burnouts at first, the burnout rate will gradually increase, reaching a peak at the average life of the group, and a few lamps will far outlive the rest of the installation.

It is obvious, of course, that about half the lamps of any group will burn out before the average life point and the other half will exceed the average. Mortality curves generally go through the 50 per cent survival point at average life. In the past, the published curves on fluorescent lamps indicate that about 20 per cent of the product will have burned out at 80 per cent of the average life. Such a curve is the "Old Curve" shown in Fig. 2. This curve has been used to establish group relamping programs in the past.

The steady improvement in the product resulting in higher lumen output, improved lumen mainte-

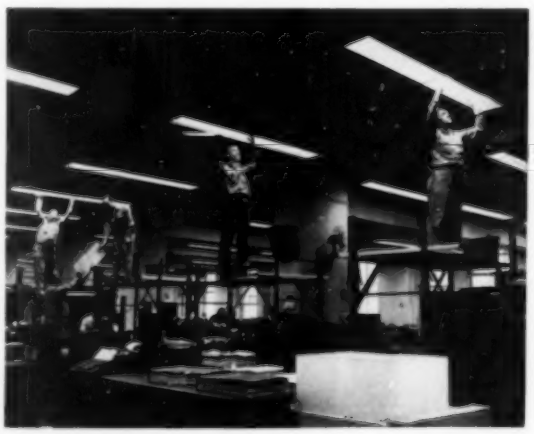


Figure 1. Efficient five-man team for group relamping with enclosed luminaire — cleaning every year — relamping every two years as they clean.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 17-22, 1958, Toronto, Ont.
AUTHOR: Lamp Division, Westinghouse Electric Corp., Bloomfield, N. J.

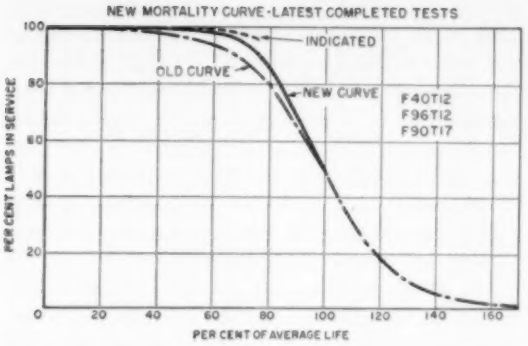


Figure 2. New mortality data on fluorescent lamps reveal improved uniformity in lamp life. Curve based on ideal laboratory operating conditions. This performance will be approximated in service with good lamps, equipment and line voltage within normal range.

nance and longer lamp life is generally known and understood in the trade. This has been the result of work on phosphors, electrodes, exhaust equipment and all of the hundreds of other factors involved in quality improvement in fluorescent lamps. These improvements have been reported but another equally important improvement has also resulted from these efforts. This is the reduction in variation of life performance between individual lamps and groups of lamps.

The reduction in life variation is chiefly due to reduced variation in the electron emission material imbedded in the electrode. Naturally there are other factors of importance but this one element has more to do with life uniformity than any other. It is the result of gradual improvements in the control of the chemical composition, the particle size, the viscosity of mix when applied to the electrode coil, and other details such as the method of application to the electrode element. The work still progresses but tangible results are revealed by more recent life test data.

New Mortality Curve

Information from the latest completed tests is given in the new mortality curve in Fig. 2. This shows a reduction of almost 50 per cent in the number of burnouts that occur before the knee of the curve is reached. It also shows that from this point on the burnout rate is higher than is obtained with a less uniform product.

Many maintenance engineers have stated that they would prefer to have the lamps so uniform in life performance that they could install them, forget them for a period of time somewhat less than the published average life of the product and then replace them a day or two before the entire lot burned out. The new curve approaches such an ideal performance more closely than the product of the past and permits a program approaching the so-called "maintenance man's dream."

There are two principal reasons why maintenance people prefer the square curve. The first is that it reduces the maintenance labor cost of "spot" lamp replacement. Actually this is a large cost item in lighting maintenance and in installations where the lamps are difficult to reach, this cost is extremely high, often far exceeding the cost of the lamp. The second big reason is that random or spot relamping is a source of general annoyance in the area involved. It also results in expensive work interruptions, with workers unable to resist the temptation to declare a temporary holiday and watch the relamping crew do its work. It has been said by some that they would be willing to pay twice as much for a lamp that would have a square mortality curve so that spot relamping could be done away with entirely.

The facts are that while fluorescent lamp life has become less variable it is still beyond the reach of present day knowledge and techniques to eliminate early burnouts entirely. For this reason some spot relamping will be needed in most installations. However, as will be noted from the new mortality data, spot relamping can be cut to less than half or can be almost entirely eliminated by the simple process of relamping just a little earlier than has been recommended in the past.

In addition to increased savings due to reduction or elimination of spot relamping, it is now also possible to burn lamps longer without encountering excessive outages. This means that less of the usable lamp life is thrown away. However, examination of the shape of the new mortality curve shows that

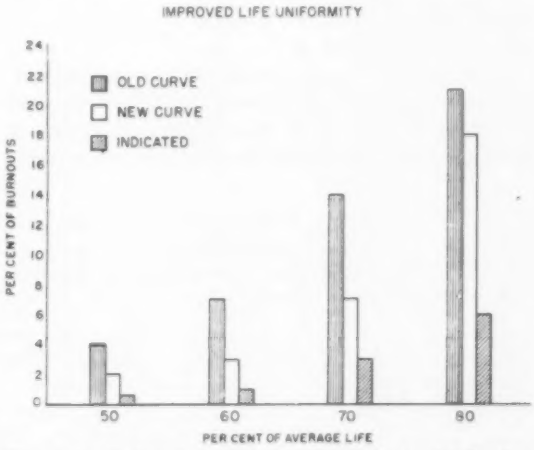


Figure 3. Reduced variation in lamp life is chiefly the result of closer control of electron emission compound imbedded in lamp electrodes. Most significant change is at 60 to 70 per cent of life.

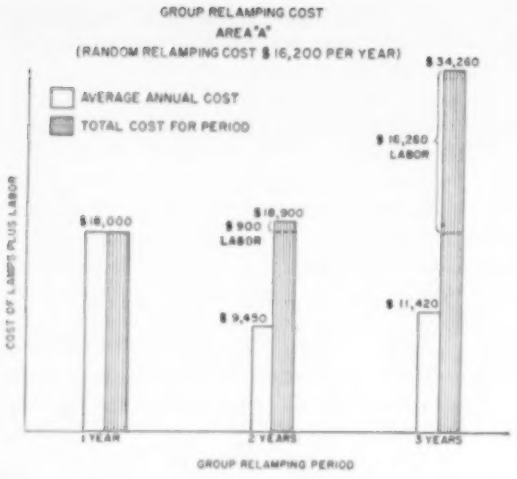


Figure 4. Two-year relamping scheduled at cleaning time is best for efficient office with enclosed luminaires. This provides low cost, top lighting maintenance and minimum work interruptions.

group relamping is more of a "must" than it used to be. The reason for this is that the outages occur at a faster rate between 80 per cent and 90 per cent of average life. With more uniform lamp life, it is impossible to maintain good operation in the lighting system during this period of high mortality with a normal size relamping crew. On the one hand, the square curve is important in that spot relamping is reduced or eliminated and, on the other hand, the square curve makes random lamping of a lighting system less practical and makes group relamping, before the knee of the curve is reached, almost compulsory.

Case Studies

Single-Shift Office — Enclosed Luminaires — Overtime Servicing

An example is perhaps the best way to explain the advantages of simplified group relamping and how such a program is best carried out. One of the most important recent installation studies, Area A (see Fig. 4 and Table I), is the lighting system used by an insurance company in their headquarters office building in New York City. There they use enclosed luminaires with 40-watt rapid start lamps. The lighting system is a highly effective one and the best lighting is required. Work interruptions are objectionable. Spot relamping is rather expensive, yet in order to maintain a high degree of efficiency in their equipment, no lamp outages are tolerated for long.

The equipment is of top quality. The operating voltage is well controlled. The burning hours and burning hours per start are known accurately. The maintenance crews are highly trained and well equipped. Washing and relamping is carried on after regular working hours.

The building is air conditioned and the air is filtered so fixture dirt is held to a minimum. It is practical here to wash the luminaires only once a year without serious reduction of lighting levels. The maintenance crew that does the washing also does the relamping every other year. By combining the two, relamping labor cost was reduced to practically nothing.

An analysis showed that the lamps burned continuously from before starting time in the morning until after office clean-up time in the evening. The lamps were not turned on and off during this period. The number of hours per start averages 15, which is also the burning hours per day. A five-day work week applies so that in a two-year cycle the lamps will have burned 7800 hours.

The new mortality curve showed that with ideal operating conditions less than 3 per cent of the lamps would be out at the end of two years. If they waited another year the estimated outages would rise to over 70 per cent. This, of course, would be intolerable and would raise the cost of labor far more than it would reduce the cost of lamps.

The cleaning crew comes around once a year and the decision was made to group relamp on every second visit based on the following:

TABLE I — Area "A" — Ideal Operating Conditions
24,000 F40T12 Lamps, 15 Hours per Start and per Day, 3900 Hours per Year.
Spot Relamping Cost — $1.50 per Lamp, Interim Group Relamping Cost — 15¢ per Lamp.

	1-Year Period	1½-Year Period	2-Year Period	2½-Year Period	3-Year Period	Random Relamping
Lamp Cost (Net)	$18,000	$18,000	$18,000	$18,000	$18,000	$18,000
Per Cent Out in Period (New)	0	½	2½	11	32½	100
Number Out (New)	0	120	600	2,640	7,800	24,000
Cost Spot Relamp (New)	0	$ 180	$ 900	$ 3,960	$11,700	$36,000
Per Cent Out (Old)	0	0	0	20	39	
Number Out (Old)	0	0	0	530	3,040	
Cost Spot Relamp (Old)	0	0	0	$ 795	$ 4,560	
Cost Interim Group Relamping at 15c	0	$ 1,800	0	$ 1,800	0	
Cost Lamps and Labor (Period)	$18,000	$19,980	$18,900	$24,555	$34,260	$54,000 (3⅓ Years)
Cost per Year	$18,000	$13,330	$ 9,450	$ 9,830	$11,420	$16,200

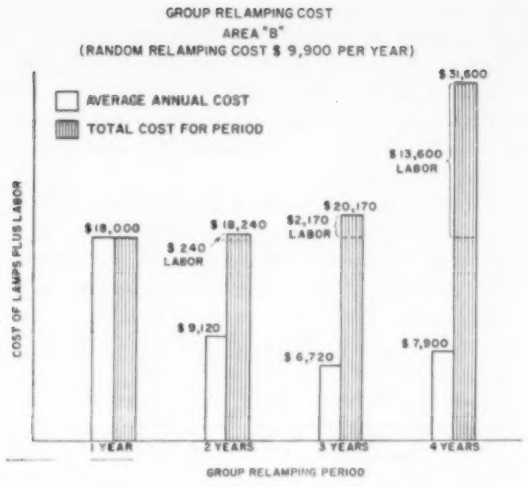


Figure 5. Group relamping should be done before knee of the mortality curve is passed. Spot relamping costs and lamp outages increase enormously beyond that point.

(1) The actual mortality curve that applies in this specific installation can only be determined after a few years experience.

(2) At the beginning, in any situation, it is wise to allow a factor of safety by relamping early rather than late.

(3) The cleaning crew visits each luminaire once a year. For this reason the choice of relamping time was limited to whole year intervals so that special group relamping visits could be avoided.

(4) A 2-year period on the curve would indicate less than 3 per cent outage up to relamping time. In some areas this could be tolerated without necessitating spot service cost and work interruptions between group relampings.

(5) Use of a 3-year relamping period, however, would result in an excessive number of outages requiring thousands of spot relampings and adding cost and annoyance.

(6) Once per year is too frequent, three years was too long a span, so a two-year period was the proper choice.

Open Luminaires Serviced During Working Hours

Similarly other representative installations with more or less burning hours per day and per year with different equipment and labor rates for lamp replacement have been analyzed. Two situations, Areas B and C, are described in Figs. 5 and 6 and in Tables II and III.

Where the labor cost of random relamping is high as in Area A, the economies resulting from a two-year relamping schedule are large. As indicated by the chart for Area B (Fig. 5), however, where spot relamping is less costly, the average annual cost with ideal operating conditions would reach a theoretical minimum on a three-year basis. Extending the group relamping period to four years would be entirely impractical as is shown. The extra cost for random relamping would be as great for the fourth year as the total cost of lamps plus relamping labor for two complete years of a three-year program.

However, in three years, with ideal conditions the outages of new lamps would reach eight per cent and of the reused old lamps about twelve per cent would also burn out. With less than ideal conditions, of course, far more than these percentages would fail. Therefore, the operator should generally relamp such an installation on a less than three-year schedule, and two years is recommended.

A two-shift factory, Area C, illustrates the economic factors involved in such a situation. Table III shows that theoretically the most economical operation would be obtained with a two-year group relamping period. This also shows, however, that a one and one-half-year period would not be much different in cost and that it would result in far fewer outages. Therefore, a one and one-half-year relamping schedule is recommended for installations like Area C.

Three-shift operations under conditions similar

TABLE II — Area "B" — Ideal Operating Conditions.
24,000 F40T12 Lamps, 10 Hours per Start and per Day, 2600 Hours per Year.
Spot Relamping Cost — $1.00 per Lamp, Interim Group Relamping Cost — 10¢ per Lamp.

	2-Year Period	2½-Year Period	3-Year Period	3½-Year Period	4-Year Period	Random Relamping
Lamp Cost (Net)	$18,000	$18,000	$18,000	$18,000	$18,000	$18,000
Per Cent Out in Period (New)	1	3	8	22½	40	100
Number Out (New)	240	720	1,920	5,400	9,600	24,000
Cost Spot Relamp (New)	$ 240	$ 720	$ 1,920	$ 5,400	$ 9,600	$24,000
Per Cent Out (Old)	0	0	12	14	42	
Number Out (Old)	0	0	250	755	4,000	
Cost Spot Relamp (Old)	0	0	$ 250	$ 755	$ 4,000	
Cost Interim Group Relamping at 10c	0	$ 1,200	0	$ 1,200	0	
Cost Lamps and Labor (Period)	$18,240	$20,640	$20,170	$25,355	$31,600	$42,000 (4¼ Years)
Cost per Year	$ 9,120	$ 8,250	$ 6,720	$ 7,250	$ 7,900	$ 9,900

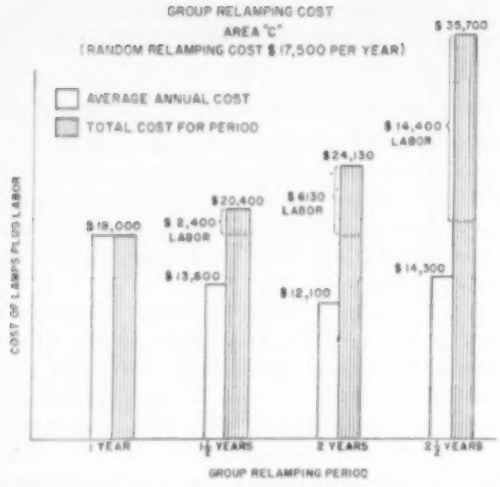


Figure 6. Most two- and three-shift operations with long burning hours per year should be relamped every 18 months. That schedule removes old lamps before they become dim and before labor costs for spot relamping become excessive.

to Area C were studied and found to be quite similar to the two-shift operation. Longer burning hours per year are almost exactly compensated for by the longer average life obtained where fewer lamp starts are involved. With ideal operating conditions, the theoretical minimum lamp and labor cost is obtained with a two-year relamping period, but the outages are excessive, being in the order of fifty per cent. Consequently, a three-shift installation should be relamped at about 18-month intervals. On this basis, spot relampings can often be omitted entirely.

The cost data involved in the studies of the three areas are given in the Tables. Only the bare essentials are included to simplify the presentation.

Ideal Operating Conditions Assumed

In each situation, a total of 24,000 40-watt T12 lamps was assumed. Relamping was done while cleaning the fixtures so that relamping labor cost was assumed to be nothing. Actually, the cost of washing the old lamp is eliminated which more than offsets the handling cost of the new lamp. All burnouts that occur between group relampings are spot relamped and the cost of this operation is shown in the tables.

No attempt was made to evaluate the cost of work interruptions due to spot relamping nor is any value shown for the better lighting obtained. The "random relamping" cost shown on each chart includes only the cost of lamps plus labor divided by average life in years, so it does not show the true comparison with the early group relamping costs shown in which the lighting is improved and outages and costly work interruptions are practically eliminated.

Selected old lamps are reused for spot relamping. The per cent burnouts for both the new lamps in the installation and the old ones used for spot relamping were determined from the "New Mortality Curve." The "Average Life" expectancy for random operation was established from the "Life *vs.* Burning Cycle" curve showing the effect of hours per start on lamp life. Total hours per year was based on full 52-week operation.

To make the three studies comparable, it was assumed that fixtures would be washed once a year. For the six-month intervals in the tables an "interim relamping" operation was necessary and its cost was added. Every other time this was done, however, it would coincide with a washing period, so the cost shown in the table is half the actual cost of each operation.

Outages due to starter failure or other causes were not included in the computations. These are just as expensive and annoying as lamp burnouts but they can be minimized. Good results are obtained when regular starters are replaced at every second relamping; no-blink (cut-out) starters at every third or fourth relamping.

Of course, the character of the installation will

TABLE III — Area "C" (2-Shift) — Ideal Operating Conditions.
24,000 F40T12 Lamps, 18 Hours per Start and per Day, 5629 Hours per Year.
Spot Relamping Cost — $1.00 per Lamp, Interim Group Relamping Cost — 10¢ per Lamp.

	1-Year Period	1½-Year Period	2-Year Period	2½-Year Period	Random Relamping
Lamp Cost (Net)	$18,000	$18,000	$18,000	$18,000	$18,000
Per Cent Out in Period (New)	0	8	19	55	100
Number Out (New)	0	1,200	4,610	13,200	24,000
Cost Spot Relamp (New)	0	$ 1,200	$ 4,610	$13,200	$24,000
Per Cent Out (Old)	0	0	33		
Number Out (Old)	0	0	1,520		
Cost Spot Relamp (Old)	0	0	$ 1,520	$ 3,300*	
Cost Interim Group Relamping at 10c	0	$ 1,200	0	$ 1,200	
Cost Lamps and Labor (Period)	$18,000	$20,400	$24,130	$35,700	$42,000 (2.4 Years)
Cost per Year	$18,000	$13,600	$12,100	$14,300	$17,500

*Amortized cost of ⅔ new lamps; impractical reuse old lamps.

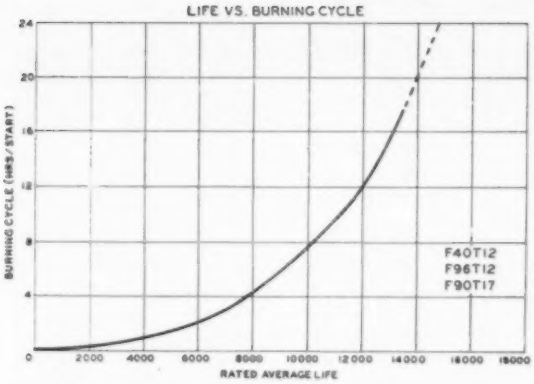


Figure 7. Approximate relationship between average lamp life and operating schedule. Per cent outages for Tables I, II and III were computed from this curve together with the burning hours per year and the new mortality curve.

affect the lamp life obtained. Good lamps, ballasts and starters, with adequate contact conditions and line voltages within the range for which the ballasts were designed, will result in full normal life. However, it is recognized that equipment that does not meet American Standard Association specifications can shorten lamp life considerably. For example, a ballast which supplies an a-c waveshape with high peak to rms current ratios could shorten lamp life by 25 per cent. This sputters off an excessive amount of the electron emission compound from the lamp electrodes at each cycle. Also, one extra lamp start per day in an average installation will advance the five per cent outage point more than six months. For these reasons, a group relamping program should be started on a conservative basis.

The new system calls for relamping when about 5 per cent of the lamps have burned out. It is made practical by improved uniformity of fluorescent lamp life which makes the old "20 per cent plan" obsolete.

The group relamping system of lighting maintenance is and should be kept simple. The charts and tables show how small are the savings and how great are the risks if the relamping period is stretched out to the theoretical economic minimum for lamp and labor cost. The best plan is the simplest — relamp at a time convenient for the washing crew and relamp early rather than later.

Of course, every installation has its own peculiar characteristics. Some operators want to relamp with a small crew working throughout the year, others bring in a big crew and do the job during summer shutdown. Lamps vary in cost and so too does the cost of replacing the burnout. Also the cost of outages and work interruptions would be hard to evaluate — we only know it is large. This report is therefore neither final nor complete. It is offered as an approach to the solution of lamp maintenance.

Summary

(1) Annual lamp plus labor cost varies only a few per cent over a range of six to twelve months in the relamping period, so the relamping time can be chosen to provide best in lighting and in general operating efficiency of area involved.

(2) Group relamping should be done by the luminaire cleaning crew while they wash the lighting equipment.

(3) Group relamping every two years is best for most single-shift operations. Multi-shift installations should be relamped every 18 months.

(4) Where starters are used, they should also be group replaced.

(5) Early relamping is the safe way. It cuts labor costs, minimizes work interruptions and removes lamps before they get dim. A new program should be started on the conservative side. Only after a few years of successful operation should longer relamping periods be considered.

(6) Group relamping saves money by reducing labor costs of lighting maintenance. It also raises lighting levels. Early relamping practically eliminates outages and work interruptions.

DISCUSSION

E. F. KELLEY:* Mr. Beggs has presented a most interesting and complete analysis of an office maintenance program. We in the lamp manufacturing business can look back and recall the resistance encountered when the group replacement plan was first suggested. It was difficult at first to consider replacing thousands of dollars worth of lamps when only 80 per cent of their average life had been consumed and 17 per cent of the lamps had burned out. As presented, this paper proves that it is both logical and economical, in certain instances, to even consider a 3 per cent burnout replacement plan.

In the program initiated by Champion in 1951, the replacement of lamps based on a 17 per cent mortality at 80 per cent of rated life was our actual rate at that time. Figs. 2 and 3 of this paper show an apparent discrepancy in the new curve failures at 80 per cent life. Fig. 2 indicates about 15 per cent failures whereas Fig. 3 shows 18 per cent in the bar graph.

The author mentions the steady improvement in lamps over the last few years and uses this as the basis for his new plan for group relamping. He also states that: "It is recognized that equipment that does not meet ASA specs can shorten lamp life considerably." He also illustrates the harmful effects of high crest factor in a ballast. It is known there are a very large number of uncertified ballasts in use. Would the author care to recommend this program of group relamping on any but certified ballasts?

The cost studies indicate that used lamps from the previ-

*Champion Lamp Works, Lynn, Mass.

ous change be used in the random replacements needed before the group replacement period. It would seem that an organization aware of the value of good lighting to a point where they will change their entire lighting system after only 5 per cent of the lamps have failed would use new lamps for their random replacements; perhaps this can be justified.

This paper is quite a radical change in the previous group replacement thinking. The author has the experience of putting this plan into service. In view of past sales resistance to this program of lighting maintenance, how extensive does the author feel this new plan will be?

FRANCIS CLARK:* The information Mr. Beggs gives regarding the improved, steeper mortality curve of fluorescent lamps is important to every lamp user. For them, knowledge of this new curve and use of these lamps can result in direct financial gain and indirectly so in reduction of interim burnouts — replacement of which can be quite a nuisance.

This knowledge is especially pertinent to those of us who are responsible for maintaining lighting systems. Steeper curves both permit and require more accurate cleaning and relamping programs. A minimum level, or an average level, specified by the user, can be more easily provided.

It should be remembered that, in planning cycles, while depreciation of lamps and accumulation of dirt on lamps and luminaires is important, it is also necessary to consider losses due to dirt on other surfaces — walls, ceilings, etc. Consideration often needs to be given to color and density of furniture or machinery. In attempting to reach the lowest cost per footcandle, as Mr. Beggs points out, individually these factors may be small but collectively, they may become important.

It appears that group replacement of fluorescent lamps can be further refined by relamping partially, and selectively, instead of relamping 100 per cent at one time. In Mr. Beggs' single-shift office example it was thought that the best cleaning cycle was annual; the best relamping cycle bi-annual. One could clean each year and relamp 50 per cent each year. Mr. Beggs' proposal might then be improved in the following ways:

1. By making the 50 per cent change selective, many lamps which might otherwise fail during the coming 12-month period can be detected and removed during the annual cleaning. This will certainly serve to reduce interim burnouts during the given two-year period. Even 3 per cent burnouts in 24,000 lamps will result in 720 labor trips. Saving in number of trips, by removing lamps, during cleaning, before they fail, must mean a financial gain to the user.
2. The lighting level will be more even from year to year. Smaller drop before relamping; lesser rise after relamping — because only 50 per cent are replaced at any one time. Average footcandles during the two-year period will be very nearly the same with either plan.

Many variations can be made in this scheduling; with this steeper curve, we can devise even more closely tailored plans.

E. W. BEGGS:* I am very glad to have the discussions by Messrs. Kelly and Clark. Mr. Kelly has given this a great deal of study from the lamp performance viewpoint, and Mr. Clark is well equipped to comment inasmuch as he is now operating an excellent lighting maintenance service.

With regard to Mr. Kelly's question on the use of a group relamping program with non-certified ballasts, that is an important consideration. Non-certified ballasts can and often do shorten the lives of the lamps they operate, and this can easily be as much as 25 per cent. Because of this, a group relamping program with such ballasts should be started with a shorter burning period between relampings. This is one of several factors that must be taken into consideration when the program is planned. This is one of the reasons why I proposed that maintenance engineers start on the conservative side, that is, that they relamp early until they learn how their particular system operates.

With regard to Mr. Clark's suggestion that a partial relamping be done, I certainly agree that it will provide a more level footcandle value throughout time. It may also, as he suggests, make it possible to eliminate potential failures before they occur. On these bases, a partial relamping program is certainly acceptable.

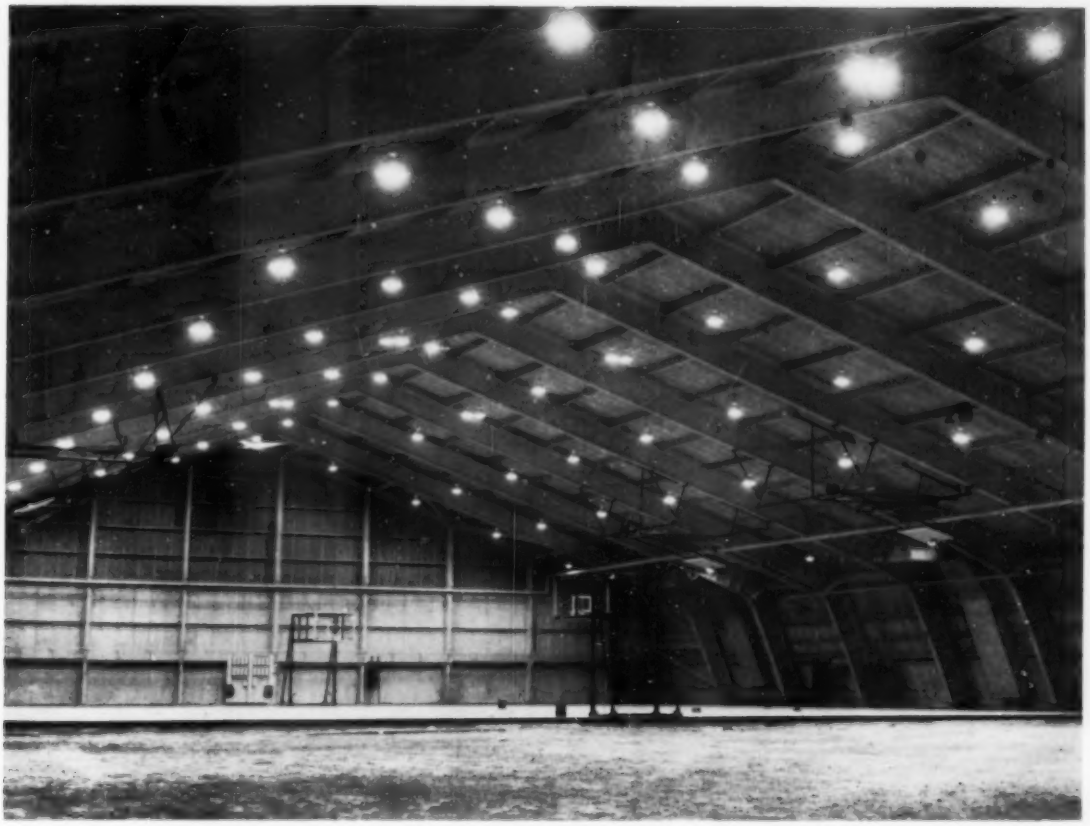
On the other hand, our own experience in our offices in Bloomfield reveals that a complete relamping cycle is also quite acceptable. The increase in footcandle levels obtained by both cleaning the luminaire and installing new lamps was, in our case, about 50 per cent. As we came in following the relamping and cleaning, most of us noticed the better lighting. It was in no sense objectionable to encounter a suddenly increased footcandle level in the area. On the contrary, higher footcandles and better lighting are so universally welcomed by those who work under the light, that I have yet to experience adverse comments because of a suddenly increased level of illumination. For this reason, it is not necessary that a partial system be used, although I certainly agree with Mr. Clark that it would provide a more uniform lighting level and therefore is certainly a refinement that should be given consideration.

*Lighting Services, Waterbury, Conn.

*Author.

IES Annual Meeting

In accordance with Article VIII, Section 1 of the Constitution of the Illuminating Engineering Society, the Annual Meeting will be held in conjunction with the National Technical Conference in San Francisco, Calif. The Meeting will be held at 10:10 a.m. at the opening session of the Conference, Monday, September 7, 1959, at which time the National Officers will report to the membership.



INSTALLATION AT HAVERFORD COLLEGE, HAVERFORD, PA.

Mercury Lighting In a College Field House

LIGHTING OBJECTIVE: To provide illumination for basketball, baseball infield practice and track events in a college athletic building.

GENERAL INFORMATION: This field house, which measures approximately 175 by 330 feet, houses a regulation size baseball infield and several basketball courts. Provisions have been made for a future balcony around the basketball courts. The ceiling, arched beams and walls are oyster white (50% RF), the basketball floor is shellacked and varnished natural maple (37% RF) and the baseball infield is dirt and cork (20% RF).

INSTALLATION: Fig. 2 shows the spacing of 89 mercury luminaires (Appleton Electric No. G-63291-V with 400-watt J-H1 lamps) and eight supplementary incandescent units (Appleton No. G-63271-V with 750-watt lamps) over the basketball court and baseball infield. These provide an average in-service illumination of 35 footcandles on the baseball infield and 37 footcandles on the

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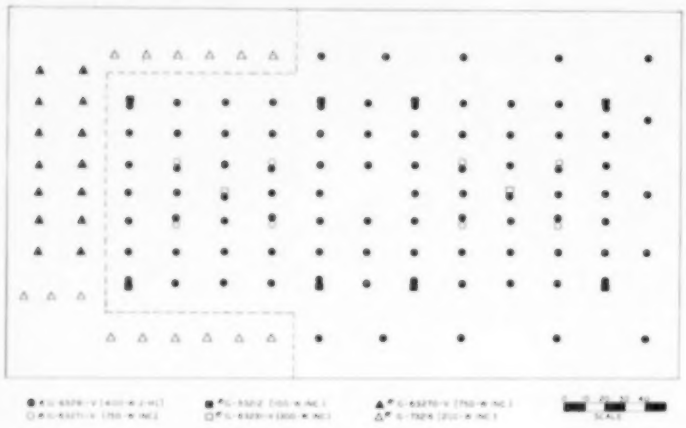

Figure 2. Plan view showing location of luminaires.

basketball court. In addition, there is an emergency lighting system consisting of ten 100-watt No. G-53212 and two 300-watt No. G-63231-V units connected to batteries. There are also fourteen 750-watt (G-63270-V) and fifteen 200-watt (G-73216) RLM units installed to light a future balcony around the basketball court. Luminaire mounting heights range from 45 feet in the center to 22 feet on the ends. All luminaires are of the high bay ventilated aluminum type manufactured by Appleton Electric Co. and are equipped with wire guards. The brightness of the mercury units is 6000 footlamberts at 45 degrees.

Lighting designed by H. B. Price and C. D. Weyman of A. E. D'Ambly, Consulting Engineer; Architects: Carroll, Grisdale & Van Alen, all of Philadelphia, Pa.

Lighting data submitted by C. D. Weyman, A. E. D'Ambly, Consulting Engineer, Philadelphia 3, Pa., as an illustration of good lighting practice and to aid in the design of similar installations.

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Some Possibilities for

Enrichment of Luminous Ceilings

By GYORGY KEPES, R. O. PREUSSER
D. E. SPENCER, L. F. MARTIN

DURING THE last decade, luminous ceilings have grown from an idea which was widely regarded as totally impractical to a well-established method of producing the optimum luminous environment. Today, installations which satisfy the requirements for best visual conditions can be seen in nearly every city.

Hitherto, the attention in luminous ceiling design has necessarily been focused on satisfying the criteria for the optimum luminous environment in the simplest possible fashion.[1] It has been the primary aim to arrange the lamps so that the diffusing medium appears to be uniformly illuminated, to suspend a suitable diffusing medium, and to make sure that sufficiently high reflectances are employed in walls, floor and furniture. Attention has also been given to the correlation of the lighting design with air-conditioning, acoustic treatment, and sprinkler systems. At the present time, nearly all luminous ceilings present a simple pattern of squares or rectangles. The means of support are visible in opaque or translucent tracks and define the geometry of the structural system. The diffusing medium is most often thin corrugated plastic or nearly flat square panels. For utilitarian purposes, these simple undecorated ceilings are entirely satisfactory.

Present luminous ceilings leave unexploited a vast realm of aesthetic possibilities. The illuminating engineer should not rest content when he has provided an adequate quantity of light and freedom from glare and deleterious shadows. As pointed out in *Lighting Design*,[2] these are only part of a well-rounded design. Two of the eight factors of lighting design suggested by Moon and Spencer deal with characteristics which are frequently ignored by the illuminating engineer. These were called the "psychological effect" and the "aesthetic effect." Lighting design provides splendid opportunities for cooperation of the artist, the architect, and the illuminating engineer. Light, color, texture and pattern can assist in making the architect's concept a significant perceptual reality.[3] Luminous ceilings can become a more versatile medium for achieving the desired individual expression of every room.

In a paper[4] presented at the I.E.S. National Technical Conference in Atlanta, Ga. in 1957, Clark and Harz took the first steps toward the introduction of color and pattern into luminous ceilings. Their building blocks were a few simple colored panels and acoustic fins. The present paper will continue the search for variety in luminous ceilings by use of pattern, texture and color. A number of possibilities will be presented. Throughout, the aim will be to satisfy the need for enrichment, while at the same time maintaining optimum conditions for seeing.

Present luminous ceilings make no attempt to exploit the inherent possibilities of transmitting light, with variety, through textured and patterned details in the diffusing medium. Perhaps one of the chief reasons why luminous ceilings are not more widely used is that many architects feel they present a problem of monotony. There is increasing concern about the search for variety and detail on which to focus. There is dissatisfaction with the aesthetic possibilities of present luminous ceilings. Other barriers to wider use are a lack of knowledge of the inherently simple design procedures and unfavorable experience with maintenance.

This paper will consider the way in which luminous ceilings of the future may be enriched and overcome present sources of difficulty by studying architectural criteria, visual criteria and structural criteria.

Architectural Criteria

The architect's aim is to create functional, legible and expressive space. Illumination could be an important factor in achieving this aim. A pressing problem is beginning to appear in the need for a critical evaluation of the psychological processes which determine the qualities associated with any

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 17-22, 1958, Toronto, Ont.
AUTHORS: Professor and Assistant Professor of Visual Design, Department of Architecture, Massachusetts Institute of Technology, Cambridge, Mass.; Associate Professor, University of Connecticut, Storrs, Conn.; President, Mariux Corp., Billerica, Mass.

experience, including the experience derived from illumination. The public, exposed to the wealth of illumination facilities available today, has gradually become more aware of its own needs, and is now demanding more differentiation and greater latitude in the solution of illumination problems. People are more conscious of light, color and space; they look forward to using tools and techniques of illumination which meet, more fully, their psychological and aesthetic needs.

Luminous space must be molded as a sculptor molds his clay. The light source, the forms in space and the textures and color of these forms constitute, in actuality, a single light space. This means that every surface is itself a secondary source of light, and the luminous environment is the result of the interrelation among all these sources. The full consequence of recognizing this interdependence between the light source and the spatial surroundings is a shift of emphasis from the type of light source which lives an independent life to a light source which cooperates with the reflecting surfaces in space. The lighting should not be an appendage to the expression of the spatial form but should be integrated into the architectural pattern.

Spacial form can be emphasized by using *contrasting* textures for the surfaces that are to be differentiated. As has been pointed out by Gibson,[5] a major factor in our recognition of the location of surfaces in 3-dimensional space is provided by recognition of *textural gradients*. Thus, the form of a solid object is recognized if the surface possesses details whose variation in size and shape are readily interpreted as indicative of position and curvature in space. These details make the space pattern legible. Yet, they should be sufficiently subdued so that the architectural forms are more prominent than the surface details which serve to define them.

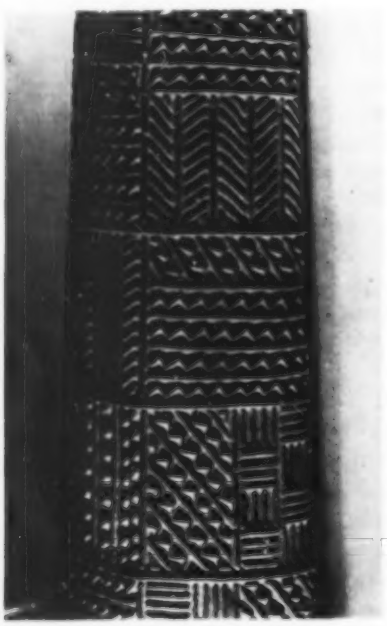

Figure 1. Texture in native carving, Pacific Islands, Peabody Museum, Cambridge, Mass. Photograph: Kepes.

From the architect's point of view, it is desirable that the luminous ceiling be free of strong pattern such as would be imposed by heavy structural members. The pattern should be subdued, yet it should provide interesting detail which the eye can explore with interest and pleasure. The ceiling should be defined in position and extent, by textural gradients. Color and interesting pattern can cooperate in providing the gradients, but great care should be taken to keep the details sufficiently delicate and subdued so that they do not forget their subordinate architectural purpose and shout their individuality.

The creation of mood and the provision of suitable decorative detail is secondary to the primary purpose of defining the architectural space, yet the architect should have the chance to express the individuality of a room. In this, color of light source and texture of the ceiling are just as important as color and texture of walls, floor and furniture in the room.

Today there is a significant tendency everywhere to work on a modular basis. A single structural element may be designed in such a way as to provide many combinatory possibilities. Patterns latent in the modular pattern may be built by a regular arrangement of the elements. A standard element may be designed so that every random arrangement produces a pleasing ceiling that transmits its light through texture and pattern. An added advantage of a 3-dimensional pattern in the plastic panels is that it strengthens the material.

A uniform distribution of light incident on the plastic should be obtained if spacing of lamps and depth of plenum are suitable. However, due to structural limitations or lack of sufficient space for proper depth of plenum, the incident light is often distributed non-uniformly. If the non-uniformity is carefully predicted, the resulting shadows could very well be used as a constructive design element by properly integrating them into the patterned texture of the ceiling.

Visual Criteria

Luminous ceilings have been developed to satisfy fundamental visual criteria for all locations in the

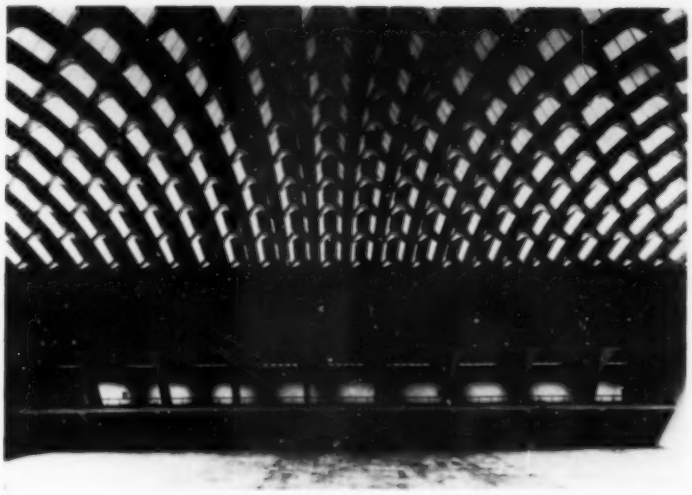

Figure 2. Roof of an exhibition hall, Turin, Italy. Architect, R. Biscaretti de Ruffia; Engineer: Luigi Nervi; Photograph, Moncalvo.

room and for all lines of sight. No matter how the eye roves over the field of view, the state of adaptation is not radically changed; one can see his work without noticeable re-adaptation whether he has looked at it for a long period and become completely adapted to it or whether he has just been gazing at the ceiling or floor. Direct and reflected glare are eliminated for all lines of sight; deleterious shadows do not occur yet there are sufficient soft transparent shadows for optimum modeling of the human face. The contrasts are controlled so that they do not become harmful to seeing, yet all the interest and variety that can be caught in a kodachrome photograph are preserved.

For the design of an optimum luminous environment, the basic criterion, derived from basic visual research, has been the preservation of a 3:1 adaptation criterion[6] for all lines of sight. Thus, if we take the state of adaptation for the work as our reference, there should be no line of sight for which the state of adaptation is raised or lowered by more than a factor of 3.

When texture and pattern are introduced into luminous ceilings, this should be done in such a way that the basic adaptation criterion is still satisfied. This means that, as the eyes rove over the ceiling, changes in the state of adaptation should not be noticed. As the state of adaptation is primarily determined by the light received in the foveal region, this means that any detail which is large enough to fill the fovea should not introduce a variation of more than 3:1. Thus, if a dark supporting member or a decorative detail of the design is large enough to fill the solid angle subtended by a dime held at arm's length, it should not vary from neighboring regions (up or down) by a factor of more than three. However, if the detail is so small that it subtends only a small part of the foveal region for normal viewing angles, then higher contrasts are permissible. For a particular detail, the maximum permissible contrast may be calculated from the basic equations which define the state of adaptation.[7]

As luminous ceilings have been designed and constructed hitherto, the plastic panels have been almost perfectly diffusing. Consequently, the ceiling is always somewhat brighter than paper work on the desk. In small rooms this ratio can be kept within 3:1 and in very large rooms it may approach unity. Nevertheless, in all finite rooms lighted with

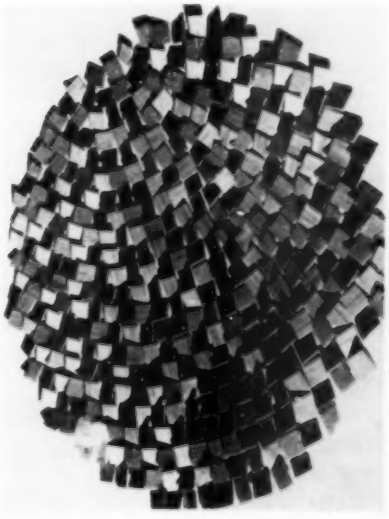

Figure 3. Design for textured acoustic ceiling by Dorothy Pelzer, student of Professor Kepes.

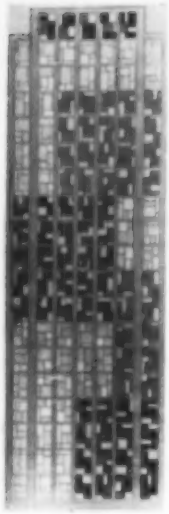

Figure 4. Theo von Doesburg design for stained glass window, 1924. Photograph: John D. Schiff.

perfectly diffusing luminous ceilings, the ceiling is necessarily slightly brighter than anything else in the field of view.

For some purposes, it would be preferable to have the work at desk level appear brighter than the ceiling (for normal viewing angles). This can be attained if the luminous ceiling employs panels that are not perfectly diffusing. The transmittance of such a panel should be maximum in the vertical direction. Yet this maximum must be restricted sufficiently so that reduction of contrast in the printed page is not perceptible. In no case should the transmittance of the plastic sheet in the vertical direction be so great that images of lamps can be detected when one looks straight up at the ceiling.

Ordinary louvered ceilings do not satisfy the proposed criterion, for with louvered ceilings the reduction of contrast and reflected glare are the same as with bare lamps. The aim is to control the light sufficiently, even in the vertical direction, so that reflected glare is imperceptible, yet to design the plastic so that maximum transmittance is in the vertical direction and the ceiling viewed from more normal angles appears less bright than the work.

For most applications it is important for the color of the light to remain essentially unchanged after it has been modified and redistributed by the luminous ceiling panels. If this criterion is to be satisfied, luminous panels may employ color but only in carefully controlled amounts. If *large areas* of the luminous ceiling are to be tinted, the colors employed must be of *low chroma* and *high transmittance*. On the other hand, *highly saturated colors* may be used, provided they are restricted to *small areas*. Completely colored luminous ceilings would be neither economical nor satisfactory in any room in which objects are to retain their normal appearance. However, they may be used to create special moods provided the 3:1 adaptation criterion is satisfied.

Structural Criteria

In the realization of new forms of luminous ceilings, a new set of structural criteria are needed. From a practical standpoint, it is desirable to allow the architect maximum freedom in his designs, yet minimize the maintenance required and make installation as simple as possible.

The ceiling is to become a blank canvas on which the architect can create any desired texture or design, with maximum freedom. This means that supporting tracks which restrict present designs must be eliminated. The supports must be concealed above the luminous ceiling and be made invisible. The plastic ceiling itself should be made up of modular elements that fit together with unobtrusive junctions. All modular plastic panels should be designed to fit into the same supporting structure. Thus, various designs may be made by simply interchanging elements and radical changes may be attained simply by substituting one set of panels for another. Aside from aesthetic advantages, the criterion of complete interchangeability, both in position and orientation, seems to dictate the use of square panels.

For ease in installation, the panels should be small enough to be handled comfortably by one man on a ladder. A foot-square modulus satisfies this requirement and also fits into any room shape with a minimum number of irregular edge sections or with a very narrow border. Convenience of actual fastening process is of great practical importance. Use of a small module permits easy access for relamping at any location in the ceiling. Throw-away panels of thin plastic could eliminate costly maintenance through periodic group panel replacement at the time of group lamp replacement. This group panel replacement presents an opportune time to make a major or minor change in the room appearance by selecting a different design in whole or in part. If a panel element is developed that can be inserted in random orientation, it will allow the workman to insert the panels in a satisfactory manner without considering their relation to an overall pattern.

Modular Patterns

By arranging the basic module in a regular fashion, a latent overall pattern can be developed in various ways, yet a random arrangement of the panels is also interesting.

Effect of Varying Depth of Detail

A method of producing a sheet whose transmittance is a function of angle is to employ a panel with very deeply moulded details. In the vertical direction light travels through only one layer of plastic, at other angles it must pass through three, five, seven or more layers of plastic.

Depth of detail can also be employed to counteract a non-uniform initial distribution of incident light. Suppose that the maximum depth of luminous ceiling is so small that the incident light on the plastic is very non-uniform, with stripes produced by the fluorescent lamps. The non-uniformity can be counteracted and any residual non-uniformity can be made to look intended by varying the depth of details from axis to edge and using a pattern with axial symmetry.

Use of Color

Colors can be used to accent legibility, as a decorative accent, and to express a mood. If color is used in large areas, it must be restricted to high transmittance and low chroma. The choice of colors is thus restricted, and the possibilities of color harmonies are limited.[8] If small areas are used in a regular pattern, intense colors can be used. There is more freedom to design color harmonies. Another possibility is to use flecks of very small colored areas arranged in a random pattern. Here, most highly saturated colors can be used while retaining a subdued ceiling texture. Color in luminous ceilings is complicated territory and warrants much experimentation.

Conclusions

This paper has outlined some methods of enriching the luminous ceilings of the future. They are to be thought of as providing an architectural building block which will be available in many types of patterns, all of which fit into a single invisible modular supporting structure. The architect can then choose the texture, pattern and color detail of the panels to define the ceiling as boldly or in as subtle a manner as he wishes. With a wide range of possibilities, luminous ceilings can play a part in expressing the individuality of every room. Yet the decorative, enriched luminous ceilings of the future will be designed to continue to provide the optimum luminous environment for human vision. It is hoped that some of the possibilities described here will be useful in making luminous ceilings an expressive architectural design element for all types of rooms.

References

1. Moon, Parry, and Spencer, D. E.: "Luminous-Ceiling Lighting," ILLUMINATING ENGINEERING, *Vol. XLIV*, No. 8, p. 465 (August 1949); "Interflections in Coupled Enclosures," *Journal of the Franklin Institute*, Vol. 250, p. 151 (August 1950); Spencer, D. E.: "Luminous Ceilings at Brown University," ILLUMINATING ENGINEERING, Vol. XLV, No. 8, p. 500 (August 1950); Spencer, D. E., Headley, R. B., Martin, L. F.: "Luminous Ceiling Lighting for a Machine Shop," *ibid.*, Vol. XLVI, No. 1, p. 26 (January 1951); Moon, Parry, and Spencer, D. E.: "How to Design Your Luminous Ceilings," *ibid.*, No. 6, p. 295 (June 1951); Spencer, D. E.: "Luminous Ceilings and Radiant Heating," *Progressive Architecture*, p. 105 (September 1951); Spencer, D. E., and Martin, L. F.: "Time *Vs.* Luminous Ceilings," ILLUMINATING ENGINEERING, Vol. XLVIII, No. 5, p. 268 (May 1953).

2. Moon, Parry, and Spencer, D. E.: *Lighting Design*, Addison-Wesley Press, Cambridge, Mass. (1948).

3. Kepes, Gyorgy: *Language of Vision*, Paul Theobold, Chicago, Ill. (1951); *The New Landscape in Art and Science*, Paul Theobold, Chicago, Ill. (1956).

4. Clark, G. S., and Harz, R. E.: "Footcandles, Footlamberts — What Next?" a paper presented at the National Technical Conference of the Illuminating Engineering Society, Sept. 9-13, 1957, Atlanta, Ga.

5. Gibson, J. J.: "The Perception of the Visual World," Houghton Mifflin Co., Boston, Mass. (1950).

6. Moon, Parry, and Spencer, D. E.: "A Simple Criterion for Quality in Lighting," ILLUMINATING ENGINEERING, Vol. XLII, No. 3, p. 325 (March 1947).

7. Moon, Parry, and Spencer, D. E.: "Visual Data Applied to Lighting Design," *Journal of the Optical Society of America*, Vol. 34, p. 605 (Oct. 1944); "The Visual Effect of Non-Uniform Surrounds, *ibid.*, Vol. 35, p. 233 (March 1945).

8. Moon, Parry, and Spencer, D. E.: "Geometric Formulation of Classical Color Harmony," *Journal of the Optical Society of America*, Vol. 34, p. 46 (Jan. 1944); "Area in Color Harmony, *ibid.*, p. 93 (Feb. 1944); "Aesthetic Measure Applied to Color Harmony," *ibid.*, p. 234 (April 1944); "An Engineering Correlation of Room Colors," *Journal of the Franklin Institute*, Vol. 247, p. 117 (Feb. 1949).

DISCUSSION

WILLARD ALLPHIN:* The authors have certainly presented a stimulating challenge to designers of luminous ceiling systems and equipment. However, one might wish that they had carried their study further, into the area of specific suggestions. My feeling is that the present paper says either too little or too much. That is, it departs from the philosophical approach sufficiently to discuss sizes and support requirements, but gives no clue as to how the apparently "insoluble" problems may be solved. For example, "All modular plastic panels should be designed to fit into the same supporting structure," yet "supporting tracks which restrict present designs must be eliminated." Still more difficult is the requirement that: "The supports must be concealed above the luminous ceiling and be made invisible."

It is hard to agree that using a foot-square modulus would permit "easy access for relamping at any location in the ceiling." It would seem that either the small pieces of plastic would have to be clipped together into groups, or pieces of the supporting structure would have to be removable in order to replace eight-foot lamps.

These points may be quibbles. They are really meant to express the hope that the authors will use their previously demonstrated ingenuity to show us some practical examples in another paper.

E. W. COMMERY:** This paper, a most challenging one, touches upon a substantial number of design factors, including some references to the need of establishing design evaluation criteria. An adequate discussion might easily be of greater length than the original. My observations, however, will be limited and will refer more specifically to those interiors which must satisfy the activities and emotional aspects associated with family life.

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**Formerly with Application Engineering, Large Lamp Dept., General Electric Co., Cleveland, Ohio; now retired.

At this time I feel that luminous ceilings as we now use them are very acceptable for the functional rooms of the home. However, they are often improved when additional light is directed at the head and face for the more critical tasks, such as make-up and shaving.

I feel we should always be mindful of the fact that the luminous ceiling which employs a highly diffuse material is classifiable as a "large area diffuse downlight" and when it is used in rooms having high reflectances, it is low in modelling power. This distribution characteristic in itself suggests that it may need shielding if it is to be acceptable in rooms devoted primarily to the social activities of family life. In an experimental room we reported in 1955,[1] it was noted that the preference for a luminous ceiling was increased when light from additional areas, such as walls, was added for both reading and relaxation. At that time also, we became aware of the need for lowering the brightness of the luminous ceiling to values substantially below those often used in commercial interiors. To increase the acceptability of given values of luminous ceiling brightness levels, two or three avenues were open:

(1) Added light from other areas;

(2) Some form of louvering system below the ceiling;

(3) Marked change in the basic light distribution of the ceiling material itself.

All of these may be seen in use, although they have not all been widely used. Louvering below the ceiling is becoming more prevalent as the desired amounts of light increase. A substantially modified light distribution is now available from at least one manufacturer who uses clear molded acrylic plastic to reduce light in the upper zones toward the eye. At the same time, this design provides scintillation which adds substantially to the designer's tools for effect and effectiveness.

The authors are to be complimented for drawing our attention to the problem and also for their formulation of the luminous ceilings in which we have no conscious feeling of supports or mechanics. Ceilings of plaster using applied ornament were once held in great esteem. Why shouldn't we turn more of our attention to the apparent design of the luminous ceiling? In doing so we may also achieve a greater control of the visual acceptance of this new lighting design technique at all useful lighting levels.

1. Commery, E. W.: "Luminous Interiors for the Home," ILLUMINATING ENGINEERING, Vol. LI, No. 6 (June 1956).

G. W. CLARK AND R. E. HARZ:* Perhaps one of the most significant aspects of this paper is not to be found in the paper as such. Many of us have long recognized the three "P's" of illumination — physics, physiology and psychology. It has been with great satisfaction that we have noted the increasing activity and subsequent contributions to our field by people in the psychophysiological fields. Psychologists and ophthalmologists, for example, are much more evident than ever before in their association with IES, both at the national and local levels. We believe it is fortunate indeed that we can add to this broadening aspect of our progress a man as outstanding in the field of visual design as Professor Kepes. Having had the privilege of being exposed to Professor Kepes' instruction for a brief period, I (G. W. C.) believe it is important to realize that his approach to visual design is a most comprehensive one. In it, esthetics and the psychological effect tend to merge. We certainly hope this paper foretells continued contribution to the illumination field by Professor Kepes and his associates and others with similar interests. Our thanks to Dr. Spencer for her part in bringing their talents to the Society.

Naturally, we can only be pleased that the authors refer to our 1957 paper[1] as a "first step" in the introduction of color, form and texture into the field of translighted ceilings. Certainly, the present paper is strong support for the "cause" in which we believe so thoroughly — the importance of the esthetic and psychological aspects of lighting. Furthermore, the authors can speak with far more authority in this field than we were able to do as engineers.

We assume that the paper's statement that "present luminous ceilings make no attempt to exploit the inherent possibilities" (of texture and pattern) was not intended to be taken too literally. Our own paper reported at least an attempt. In the year which has followed, we can report that the interest in this attempt has been sufficiently successful to encourage us to add to the scope of design possibilities by the further additions of color and panel forms. We find, however, that the concept is not an especially comfortable one for most engineers. It will undoubtedly require a period of "living with" the ideas expressed in both our own paper and the present one.

To cope with the engineer's reluctance to attempt esthetic design with our ceiling system, we have found it necessary to publish some general "rules" of the application of color elements. We are pleased to find that they coincide with the suggestions of the authors here, and can report that they seem to work well. While the average engineer cannot be expected to produce designs equal to those of professionals in this field, such as architects, industrial designers and interior decorators, we believe they can, when required, do a satisfactory job for the average installation by applying a few simple guides, if the design components are not made too complex.

With respect to the brightness of highly diffuse shielding, as the authors point out, the control of this brightness at high levels of illumination can be a problem. It has been our intuitive opinion, however, that when a total ceiling design is introduced, the apparent ceiling brightnesses do not necessarily follow the measured ones. While we have, at present, no test data to support this belief, it is perhaps significant that Dr. Hopkinson suggests that in his glare tests for extended area sources, the introduction of texture to the source changes the results.

Our experience indicates, as the authors suggest, that non-uniformity of brightness, due to lamp spacing and cavity obstructions can be counteracted by design details in the shielding medium. Of course, in the general situation it is sometimes difficult to anticipate accurately the erratic variation of this non-uniformity. One favorable factor in this situation is that people seem to have a greater tolerance of any brightness variation where color, form and texture are introduced.

Referring to the panels displayed as part of the presentation of this paper, we would agree that they are very attractive. Their appearance was undoubtedly enhanced by the diminution of the normally evident module line. This is a challenging mechanical design problem, considering the requirements of the various codes and regulations which govern the installation of luminous ceilings.

We question whether the appearance designs of the panels are not too subtle for most applications. While the ceiling should not appear overpowering or garish, its design should be significant. We have had in luminous ceilings, for several years, white panels of many formed designs which when viewed at a distance lost their distinctive appearance. Isn't this perhaps similar to the effect of the ceiling when

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Figure A. (Clark-Harz discussion). Color, form and texture are incorporated into the design of this translighting ceiling in a finance company office in Paramus, N. J. Designer: E. C. Thomas.

it is not the center of visual attention? To be architecturally "correct," the ceiling should be integrated into the total interior design. Doesn't this call for a ceiling design which competes reasonably with the visual impact of other elements in the field of view? The authors' comments on these thoughts would be appreciated.

The discussion of details of the design elements of the translighted ceiling system is of particular interest, although we feel the appearance design aspect of the module size should not and need not be confused with that related to installation and maintenance. It has been our experience that three- by three-foot or two- by two-foot modules are easily handled from both installation and maintenance standpoints. Furthermore, the large size is substantially more economical equipment-wise and installation-wise. From an appearance standpoint, the one-foot square module may well be achieved with larger panels and still retain the advantages of an economical and practical lighting system.

We agree that the grid system is usually of little or no significance to the esthetic design of the area; therefore it should be subdued in the over-all effect. This may most obviously be accomplished by (1) increasing the brightness of the exposed areas of grid members; (2) concealing them from normal view through the design of the diffuser form. The former has been achieved by using translucent plastic grid members and by applying a high reflectance finish to opaque members having a cross-section designed to intercept a substantial amount of illumination (*e.g.*, V-shaped). In the case of concealment, at least one system has vacuum-formed panels of such a depth as to obscure the grid members in a major part of the field of view.

The effective use of color, form and texture within the design scope of a translighted ceiling is illustrated in Fig. A, a job installed during the past year. This is not offered as evidence of the complete accomplishment of the objective expressed in this paper, but rather of the fact that a specific start has been made. The design of ceiling systems to meet the concept of this paper has just begun. Papers such as this one will do much to encourage future development in this direction.

1. Clark, G. W., and Harz, R. E.: "Footcandles, Footlamberts, What Next?" a paper presented at the National Technical Conference of the Illuminating Engineering Society, September 1957, Atlanta, Ga.

W. S. FISHER:* This paper covers a subject that is of considerable interest to many illuminating engineers. It should also be of importance to interior designers and decorators, and it is hoped that steps are taken to communicate this information to them.

One distinct possibility for decorative treatment of luminous ceilings is to tie them in with the room and its furnishings (Fig. B). This is illustrated with the luminous panels designed with a wooden frame reflecting the wood furnishings of the office. Although this is a "custom designed" lighting system, all the components are of standard manufacture. The "floating panel' luminaires now made by

*General Electric Co., Nela Park, Cleveland, Ohio.

Figure B. (Fisher discussion). Custom-designed lighting system in this office has luminous panels in wooden frames, reflecting the office decor.

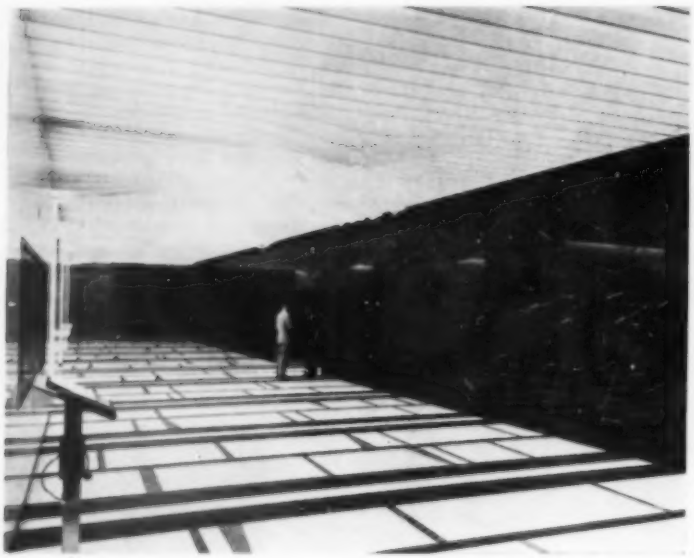

Figure C. (Fisher discussion). Sculptured baffles in luminous ceiling in Tishman Building lobby, New York City.

n number of manufacturers have similar possibilities for enrichment with decorative treatment.

The concept of introducing sculpture into ceiling systems was done very successfully by Noguchi in the lobby of the Tishman Building (Fig. C) in New York. Instead of conventional rectangular baffles, form was introduced which developed and flowed from one baffle into the next. A flow of changing color could also be applied to baffles, and an installation underway at the General Electric Lighting Institute will demonstrate this possibility.

Another variation is afforded with the standard colors now available in plastic and metal louvers. This is illustrated here (Fig. D) with two colors of plastic louvers shielding the ceiling, and white louvers under the lamps. The basic luminaire from which this lighting system was developed employs two high-output lamps of non-circular cross-section in separate "runners" separated by about 18 inches. Ballasts are in the spacers at the ends of each luminaire. The luminaires were spaced 18 inches apart and all open spaces were filled with the colored louvers. About 200 footcandles will be provided in service, when normal depreciation in lamps, luminaire and room surfaces has taken place. Form, texture and color all provide a distinctly new appearance for this installation.

D. E. SPENCER:* We wish to thank all of the discussers for their encouraging comments. All of us seem to be in agreement that much remains to be done in luminous ceiling

*Co-Author.

Figure D. (Fisher discussion). Here, colored plastic louvers "shield" the ceiling; white louvers shield the lamps. This system, using two-lamp luminaires spaced about 18 inches apart provides approximately 200 footcandles in service.

design and that texture and color provide promising methods of enriching luminous ceilings.

Mr. Allphin points out that we have formulated an *apparently insoluble problem*. The exhibits shown at the presentation of the paper at the Conference showed that much progress had been made between the time when the paper was written and the time of presentation. It has been demonstrated that modular panels with an interesting range of textures can be supported in an essentially invisible hanging system. Trials indicate that eight-foot lamps can be replaced without interference from the proposed hanging system employing foot-square panels. We hope to present a large-scale solution to the "insoluble problem" in the near future.

Mr. Commery feels that "luminous ceilings as we now use them are very acceptable for the functional rooms of the home." But, he feels that modifications are desirable "in rooms devoted primarily to the social activities of family life." We agree that luminous ceilings and luminous walls can be effectively combined. Louvering below the ceiling is an acceptable procedure, providing the horizontal sheets of plastic are sufficiently diffuse so that there is no reflected glare. However, it appears that the best way of making a luminous ceiling a *positive element* in the interior decoration scheme is by introducing texture, color and optimum angular characteristics directly into the plastic panels.

Messrs. Clark and Harz have done interesting work in introducing variety into luminous ceilings. Their solutions retain desired visual characteristics of the early functional luminous ceiling designs. However, their designs exploit only a small fraction of the "inherent possibilities" and make little use of texture as a design element. The idea that luminous ceilings satisfying the 3:1 adaptation ratio may be comfortable at any level if they contain interesting texture is valuable.

The annoyance associated with a blank area and with an interesting area are doubtless not the same, even though they may give equal photometric readings. Hopkinson and Guth should be encouraged to investigate this question.

The extent to which the visual "impact" of the ceiling should compete with that of floor or furniture is another interesting question. In nature, the upper part of the field of view is interesting, but in a subtle way. If one wishes to emphasize the architectural structure of the room and the objects placed on the floor and walls, then the ceiling should form an unobtrusive background. Cases in which the ceiling pattern should be clearly articulated seem to be the exception rather than the rule.

Mr. Fisher has kindly supplied additional examples of variety in ceiling construction. These examples all have interesting elements of variety, yet each possesses characteristics that violate basic visual criteria. One example appears to introduce mahogany bars on the ceiling to match furniture which is itself too low in reflectance. Another has a wall of dark marble. A third employs louvered high-output lamps of non-circular cross section. Installed in this way, these powerful lamps provide the most effective source of fluorescent reflected glare that is available today.

In conclusion, let us echo the theme of the 1958 Progress Report — with texture, decoration, color and departure from perfect diffusion, without sacrificing basic visual criteria, we can successfully rival daylight with the use of luminous ceilings. But, in attaining this goal, much work remains to be done which will require the close cooperation among illuminating engineers, artists, interior designers and decorators and architects.

Resolution of Intent—Relating to Table IV of the American Standard Practice for Street and Highway Lighting, D12.1—1953

Prepared by a Subcommittee on Interpretation of the American Standard Practice of the Roadway Lighting Committee of the Illuminating Engineering Society

Subject

Current recommended illumination levels contained in *American Standard Practice for Street and Highway Lighting*—D12.1—1953.

Recital

For some time it has become evident that considerable confusion exists in the interpretation of average horizontal footcandle values contained in Table IV of the Practice.

Inasmuch as limited access highway design and construction was in its infancy when the Practice was last amended, references therein for lighting such roadways are general and meager. In the face of the tremendous National Highway Improvement program such references also should be clarified and expanded within the meaning and intent of the code.

Opinion

It is the opinion and belief of the Roadway Lighting Committee of the Illuminating Engineering Society:

That it has always been the intent that the illumination values shown in Table IV should be treated as minimums after proper consideration has been given to both lamp and luminaire depreciation during operation irrespective of the method employed in maintaining the lighting system and also to future probable pavement reflectance characteristics.

That the illumination value recommended for limited access highways be expanded to consider such highways in urban areas as heavily traveled streets with no pedestrian traffic and that interchanges on such highways in such areas be treated in as near the same manner as surface street intersections in the matter of illumination.

Approved by the Council of the Illuminating Engineering Society, February 1959.

Color Preferences for Natural Objects

By C. L. SANDERS

Introduction

Since the advent of artificial sources of light, and in particular the fluorescent lamp, certain difficulties have been experienced in selecting illuminants with energy distributions which make the color of objects appear normal, that is, as they appear in daylight. Although the colors of many objects may be rendered poorly by fluorescent lamps, common natural objects are generally the subjects of complaint. It was thought that these objects might have peculiar spectral reflectance curves or fluorescence which could cause the difficulty. These properties were investigated for tea, butter, the human complexion, potato chips and raw beefsteak, because these objects are known to evoke complaints of bad color rendition.

Although some fluorescence is present when butter, tea and potato chips fried in oil are examined under ultraviolet radiation, the fluorescence is not great enough to be considered important. An examination of the spectral reflectance curves of these objects revealed no appreciable peculiarities. Instead, as shown in Figs. 1 and 2, the reflectance curves are very similar to those of paints or cloths (except for the carotene absorption bands in butter and the hemoglobin absorption bands in raw beefsteak).

Fig. 1 shows the spectral reflectance curves of a potato chip, butter and a tea infusion with milk added. The upper curve of Fig. 2 shows the spectral reflectance of beefsteak fresh from the refrigerator; the lower one is for the same beefsteak after it had been at room temperature for half an hour. This decrease in red reflectance accounts for the darkening of beefsteak when it is not refrigerated. Since lamps having a deficiency of red energy cause fresh refrigerated meat to have the appearance of meat left in a warm place, lamps lacking in red energy are not suitable for use in a meat market.

It is possible that in many other cases when the color rendition of an object is the cause of complaint, the objectionable color change indicates to the observer some lack of quality or health. The critical nature of these objects may be accentuated because the observer is consciously or subconsciously looking for the tell-tale color change. For example, a customer being aware that potatoes turn green when sun-burned would be unwilling to buy potatoes which appeared even slightly greenish in color, even if he were assured that the illuminant made perfectly good potatoes appear slightly green. Similarly a normal tea infusion made with good quality tea, will, under an illuminant with below

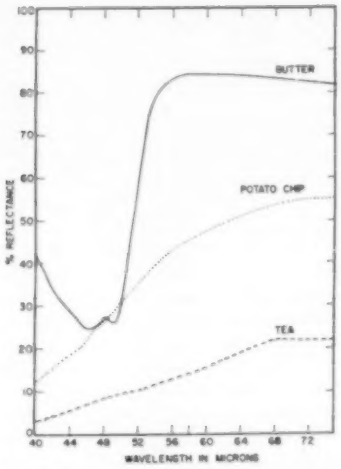

Figure 1. Spectral reflectance of natural objects

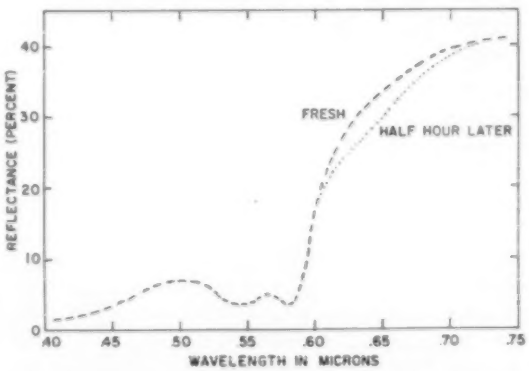

Figure 2. Spectral reflectance of raw beefsteak.

AUTHOR: Division of Applied Physics, National Research Council, Ottawa, Ont. This study is part of a Ph.D. thesis submitted to the Imperial College, University of London, London, England, in 1955. The paper was presented at the October 1956 meeting of the Optical Society of America.

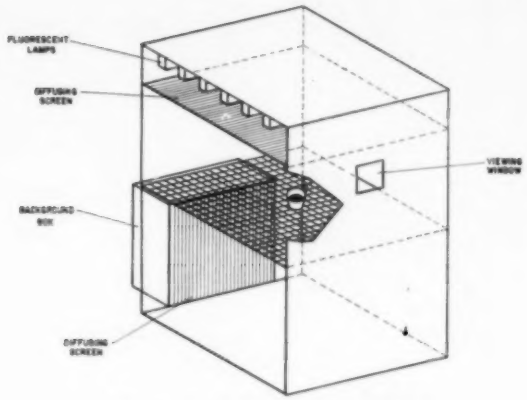

Figure 3. Color mixture booth.

normal red energy, take on the greenish appearance often associated with weak or poor quality tea.

MacAdam[1] in a study of photographic color reproduction found that in some cases the actual color of the object which was photographed was not the preferred color in a color transparency. He therefore emphasized that in any color rendering problem, the departure from perfect color reproduction should be indicated by the deviation from the optimum color and not from the object color produced by a standard illuminant. With this in mind, the observers in this experiment were given no standard color for comparison but were asked to state from memory whether or not the colors of the objects presented were satisfactory. The center of the acceptable range of colors, found in these experiments, should therefore be the optimum color for the object being judged.

It is known that if the state of adaptation is not fixed, some allowance must be made. In order to avoid the necessity for making any compensation for adaptation, a fixed white background was provided by the following experimental arrangement.

Experimental Arrangement, Procedure and Method of Analysis

The color-mixture booth, constructed as shown in Fig. 3, was six feet high, 30 inches wide and 30 inches deep. The main illumination was provided by three pairs of 40-watt fluorescent lamps.* The luminous flux from each pair of lamps could be controlled by means of a dimmer circuit such as the one described by Strange.[2] Each pair of lamps was a different color; therefore, by adjustment of three 21-step resistors, light of variable color could be produced. Since the lamp colors included green, blue and pink, a wide color variation was possible. In some cases, it was found desirable to use supplementary illumination provided by plain and colored tungsten lamps which could be switched on or off as desired. The colored light was mixed by a sheet of tracing paper on top of a piece of corrugated rolled plate glass placed about six inches below the lamps. An illumination of 20 lumens per square foot was incident on the test sample, placed on a wire mesh about 30 inches below the diffuser. The color of the test sample varied as the color mixture was changed, but in every case a fixed white background was provided to control the adaptation.

The objects were divided into two classes. In the case of the hand, the face, potato chips and beefsteak, the background was provided by a box 24 inches square and 12 inches deep at the back of the booth. The box, which contained two 40-watt fluorescent lamps,* was painted white inside and was covered with tracing paper. The color of the background could be altered by changing the fluorescent lamps, but in these experiments it was confined to the chromaticity of either CIE Illuminant *B* or CIE Illuminant *C*. It was necessary to use a pale blue tracing paper to correct for the slightly yellowish white paint and the tendency of the fluorescent lamps to be on the yellow side of the appropriate standard illuminant.

When experimenting with tea and butter, the background box was not used. Instead, a white cardboard was placed over the wire mesh to provide the background. An appropriate fixed mixture of light was used, and the color of the samples presented for judgment was varied by food coloring media. In order to obtain a stable color for tea, it was necessary to add gelatin to the tea to prevent the flotation of a white constituent in the milk.

For each object investigated an attempt was made to provide a set of colors which included unsatisfactory colors on all sides of the acceptable ones. The colors in the set were then presented in random order to the observer who was asked to say whether the color presented was found to give "good," "fair to good," "fair," "fair to unsatisfactory" or "unsatisfactory" color rendition to the sample. For the purpose of averaging repeated observations, these judgments were given the weights 100, 75, 50, 25 and 0, respectively.

Color measurements were made on each test sample from the same direction and with the same color mixture used when the sample was judged. The measurements were made with a portable colorimeter designed by Professor W. D. Wright. The

*Lamps and auxiliary equipment were kindly loaned by Dr. S. T. Henderson, Thorn Electrical Industries, Ltd., London, England.

*40-watt lamps of British manufacture, 24 inches in length.

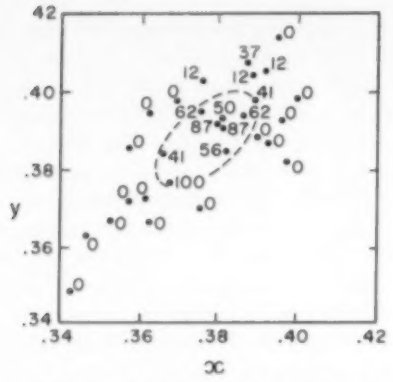

Figure 4. Example showing the chromaticities of artificially colored butter samples and the judgment recorded for each chromaticity. The chromaticity of this illuminant was x = .395, y = .415.

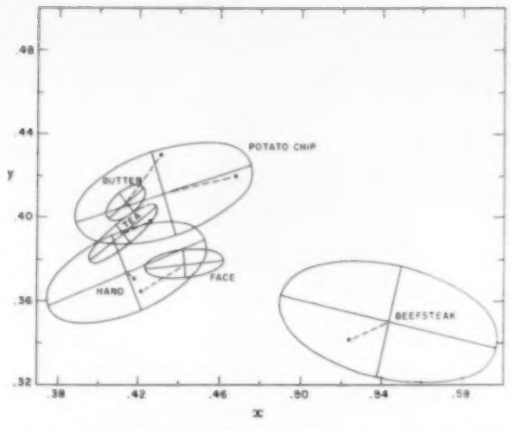

Figure 5. Color tolerance ellipses for natural objects under CIE Illuminant *B*.

instrument, which is similar to that described by Burnham,[3] was calibrated using Munsell papers and CIE Illuminant *C*. From the calibration, it was possible to determine the CIE chromaticity of each test color. By this method it is possible to find the colors which were actually judged, without knowing either the spectral reflectance of the sample or the energy distribution of the illuminant. This procedure has obvious advantages when the test samples have non-permanent spectral reflectance curves and is much more direct than the measurement of the spectral reflectance of each object followed by the measurement of the spectral energy distribution of the source and then the calculation of the color.

A typical set of observations is given in Fig. 4, where the chromaticity of each butter sample observed in one particular set is shown as a dot, with the average judgment of the color beside it. The dashed line passes through the judgments of value 50. Thus, all colors inside the curve would provide fair or better color rendition and all colors outside would produce unsuitable color rendition. These curves were elliptical and approximate ellipses were hand drawn. It would be possible to determine the best curve by a least squares method but this would involve solving a set of six simultaneous equations and could not be expected to make a significant improvement in the accuracy of assigning the curve for a given set of data.

Experimental Results

After a number of color tolerance ellipses had been obtained using several observers and different sets of colors, the average ellipse was determined by averaging the centers, the major and minor radii and the tangents of θ, where θ is the angle between the x-axis and the major axis of the ellipse. The average tolerance ellipses obtained for CIE Illuminants *B* and *C* are shown in Figs. 5 and 6, respectively. The specifications of the ellipses with the standard deviations of the means, where available, are given in Tables I and II.

For a reasonable determination of an ellipse, it is necessary to have at least 20 colors spread fairly uniformly around the optimum color. Less than this number of tea colors were available at one time and therefore all sets of data were combined for tea, and only one ellipse was drawn. Consequently, no standard deviations can be given for tea.

The observations on beefsteak were all made on one day and no colors were available which were too saturated. At room temperature raw beefsteak changes color rapidly; therefore, the colors were

TABLE I — Average Preferred Chromaticities of Natural Objects under CIE Illuminant *B* and Specification of Color Tolerance Ellipses. Standard Deviations of the Means, σM, are given where available.

Object	Chromaticity Preferred		Principal Radii of Ellipse		Tan $\theta \pm \sigma M$	No. of Sets of Observations	$[(ab)_{CT}/(ab)_{CM}]^{1/2}$
	$x \pm \sigma M$	$y \pm \sigma M$	$a \pm \sigma M$	$b \pm \sigma M$			
Hand	0.414 ± 0.005	0.374 ± 0.005	0.042 ± 0.004	0.019 ± 0.001	0.7 ± 0.1	4	13
Face	0.443 ± 0.002	0.378 ± 0.001	0.018 ± 0.001	0.007 ± 0.0003	0.10 ± 0.03	34	6
Tea	0.412	0.392	0.021	0.006	0.8	12	6
Butter	0.414 ± 0.003	0.407 ± 0.003	0.011 ± 0.001	0.005 ± 0.001	0.8 ± .01	5	4
Raw Beefsteak	0.544	0.350	0.054	0.028	−0.2	5	21
Potato Chips	0.432 ± 0.009	0.412 ± 0.007	0.045 ± 0.006	0.021 ± 0.003	0.3 ± 0.1	4	16

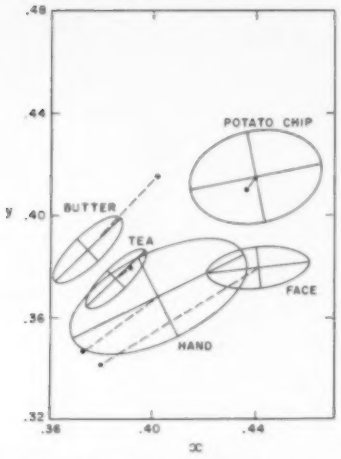

Figure 6. Color tolerance ellipses for natural objects under CIE Illuminant *C*.

measured several times at short intervals and the chromaticity was interpolated to the time of observation. Even so, the result for beefsteak is doubtful. Furthermore, it appears that the lightness of beefsteak is more critical than the chromaticity. An attempt was made to determine a lightness tolerance by observation, but it was unsuccessful because the lightness seemed to depend on the placement of the sample in the booth, probably because the texture of beefsteak is such that there are small glossy facets at various angles and the source of light is reflected by these into the colorimeter with an unpredictable effect. These difficulties might be overcome if the color change due to deterioration of the meat could be prevented by working in a walk-in refrigerator. Such a refrigerator was not available, however, so the work on beefsteak is incomplete, and the ellipse given is questionable.

In order to compare the colors of real objects under CIE Illuminants *B* and *C* with the color-tolerance ellipses, spectral reflectance curves of actual objects were obtained. The chromaticities calculated from these curves are plotted as solid circles on the chromaticity diagrams in Figs. 5 and 6. It will be noted that the preferred color for butter is considerably paler than the color of the actual butter sample. On the other hand, the preferred color of the face* is more saturated than the actual facial color. Although slight displacements were recorded for the remainder of the objects tested, the displacements are, in each case, less than the radii of the appropriate tolerance ellipse and are therefore not very significant.

The preference for facial colors which are more saturated than the color of the face in daylight indicates a preference for a ruddier complexion than that of the main subject, SCS. However, almost the same color preference was found when two other subjects were used. For each of these subjects, the center of the tolerance ellipse was included in the tolerance ellipse which had been obtained from the observations on SCS's face. This indicates a large overlap of acceptable color mixtures and means that an illuminant which gives the optimum color rendition for SCS's face will also be acceptable for the color rendition of the faces of the other subjects.**

It is interesting to compare these color tolerance ellipses with the standard deviation of color matching ellipses determined by MacAdam.[4] When the comparison is made for the appropriate part of the chromaticity diagram, one finds that the color matching ellipses are very similar to the color tolerance ellipses except in size. Using the square root of the area as a measure of size, the tolerance ellipses are found to be larger than the color matching ellipses by the factors indicated in Tables I and II. The factors being small for the face, tea and butter indicate that these objects are more criti-

*The whole face was judged, but the color measurements were made only on the center of SCS's (the main subject) forehead for each light mixture. Although observations were made on other subjects' faces, the judgments were always recorded at the chromaticity of SCS's forehead under the illuminating mixture. The spectral reflectance of SCS's forehead was used in calculating the facial chromaticities shown in Figs. 5 and 6.

**This is not really conclusive since all three subjects were about equally pale at the time. It is possible and, in fact, probable that if one really sun-tanned subject had been used, the observers would have preferred an illuminant with less red energy to illuminate his face. Such an illuminant would make the color of the sun-tanned subject's face more similar to the facial color which was preferred in these tests. This suggests that the ideal illuminant for color rendition of the complexion may change with the season, at least in the latitudes where sun-tans are seasonal.

TABLE II — Average Preferred Chromaticities of Natural Objects under CIE Illuminant *C* and Specification of Color Tolerance Ellipses. Standard Deviations of the Means, σM, are given where available.

Object	Chromaticity Preferred		Principal Radii of Ellipse		Tan $\theta \pm \sigma M$	No. of Sets of Observations	$[(ab)_{CT}/(ab)_{CM}]^{1/2}$
	$x \pm \sigma M$	$y \pm \sigma M$	$a \pm \sigma M$	$b \pm \sigma M$			
Hand	0.402 ± 0.011	0.368 ± 0.010	0.036 ± 0.013	0.017 ± 0.005	0.5 ± 0.1	12	12
Face	0.441 ± 0.011	0.379 ± 0.007	0.020 ± 0.002	0.008 ± 0.001	0.10 ± 0.06	16	7
Tea	0.386	0.375	0.017	0.004	1.0	10	4
Butter	0.375 ± 0.002	0.386 ± 0.001	0.017 ± 0.001	0.006 ± 0.0005	1.0 ± 0.1	9	5
Potato Chips	0.422 ± 0.004	0.415 ± 0.002	0.034 ± 0.002	0.019 ± 0.002	0.2 ± 0.1	11	13

cally judged than are the hand, beefsteak and potato chips.

The angle θ is larger for the color tolerance ellipses than for the color matching ellipses by about 20 degrees on the average. However, it should be noted that the ellipses found by Brown and MacAdam[5] also have a larger angle of θ than those reported originally by MacAdam[4] for the observer PGN. The over-all agreement between these color tolerance ellipses and the color matching ellipses is such that it seems reasonable to assume that once the preferred color for an object is known, one can assume that the color tolerance ellipses have the same orientation and shape as the color matching ellipses. Then, the only variable left to be determined is the relative size, which depends on how critically one judges the object.

Conclusions

To sum up, it may be stated that the preferred color for an object may differ from the color of the object in daylight due to psychological influences, and that the range of acceptable colors is very dependent on the object and on the extent to which its quality varies with color. The acceptable range may, in general, be represented by ellipses in the chromaticity diagram which are very similar to the ellipses representing the standard deviations of color matchings.

Acknowledgments

It is a pleasure to acknowledge the suggestions and encouragement of Professor W. D. Wright, and the numerous hours which my wife and my colleagues at Imperial College kindly spent acting as observers in these experiments.

References

1. MacAdam, D. L.: "Quality of Color Reproduction," *Proceedings of the Institute of Radio Engineers*, Vol. 36, p. 468 (1951).
2. Strange, J. W.: "The Dimming of Fluorescent Lamps, and its Application to the Theatre," *Transactions of the Illuminating Engineering Society (London)*, Vol. 15, p. 111 (1950).
3. Burnham, R. W.: "A Colorimeter for Research in Color Perception," *American Journal of Psychology*, Vol. 65, p. 603 (1952).
4. MacAdam, D. L.: "Visual Sensitivities to Color Differences in Daylight," *Journal of the Optical Society of America*, Vol. 32, p. 247 (1942).
5. Brown, W. R. J., and MacAdam, D. L.: "Visual Sensitivities to Combined Chromaticity and Luminance Differences," *Journal of the Optical Society of America*, Vol. 39, p. 808 (1949).

"Lube" jobs, car washes and other car maintenance is done under a level of 60 footcandles in the service department of this Shell station. High-output lamps, on 800 ma, are mounted in Alzak aluminum troffers, recessed in the canopy. Office area indoors also has 60 footcandles for the sale of small car parts and accessories. Lighting is by high-output lamps mounted above an egg-crate louvered molded plastic ceiling. Lighting layout and design by Bill Harrington, Engineer, Shell Oil Co., New Orleans, La., and Dave Lanham, of Gregory Salisbury Co., New Orleans. Photo and data courtesy Edwin F. Guth Co., St. Louis, Mo.

A.I.A. File No. 31-f

INSTALLATION AT STROMBERG-CARLSON DIVISION, GENERAL DYNAMICS CORP., ROCHESTER, N. Y.

Edgelighting a Plastic Mural

LIGHTING OBJECTIVE: To edgelight a carved plastic mural to emphasize and enhance the design.

GENERAL INFORMATION: The mural, which is 4 feet by 10 feet, is carved from a ½-inch thick sheet of Plexiglas. It is mounted about 3 inches in front of a green velvet drape (10 per cent reflectance), used as a backdrop against which the illuminated carved letters are to be seen. The plastic is attached to the walnut plywood wall on the bottom and left side.

INSTALLATION: Two 48-inch T-12 high output warm white fluorescent lamps, one at the top and one at the bottom, and one 96-inch T-12 high output warm white fluorescent lamp at the left side are used to edgelight the mural. These lamps, their channel and ballasts (Day-Brite catalog No. 79140) are installed in the walnut enclosures, seen above, which measure approximately 8 inches wide and 6 inches deep. Lamps are located about ¼ inch from the mural's edges.

Brightnesses of the mural's lettering resulting from the edgelighting vary from 34 to 12 footlamberts. Brightness of the background (velvet drape) varies from 1.5 to 0.5 footlamberts.

Lighting designed by Carl Traver, Architect, Rochester, N. Y. Mural designed and etched by Mrs. Cornelia Hayes, Marion, Ind.

Lighting data submitted by Joseph Phillips, Vanderlinde Electric Corp., Rochester, N. Y., as a solution to a lighting problem and to aid in the design of similar installations.

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Luminance Versus Luminous Emittance

By W. A. HEDRICH

ILLUMINATION theory, like that covering other fields of science, is subject to diversification in nomenclature. For example, the terms brightness and luminosity, as used by some authors, have now largely given way to luminance and luminous emittance respectively. The same basic definitions of brightness and luminosity have been retained in the luminance and luminous emittance concepts adopted by the Commission Internationale de l'Eclairage. These definitions appear in the *International Lighting Vocabulary*, second edition, Volume 1, published by the CIE 1957. The term "brightness" has been deleted, and luminosity has been redefined as subjective brightness, that is, "the attribute of visual sensation according to which an area appears to emit more or less light, the psychosensorial correlate (or nearly so) of the photometric quantity *luminance*."

In general it is not possible to attain over-all precise international agreement on the terminology of illumination, especially in regard to fundamental concepts. The latter, however, if they are basic to a description of vector and scalar aspects of the illumination field, are quite independent of the nomenclature. A more fortunate adoption of nomenclature is generally to be desired, especially when its phraseology embodies a unique but preferably terse description of the operation to be defined.

The discussion which follows is not focused on whether the illumination field can be completely described by deleting either one or the other of the two concepts, brightness (luminance) and luminosity (luminous emittance). Rather it accepts the definitions generally applied to them and seeks to clarify the aspects in which they differ from each other. Considerable misunderstanding still arises through failure to comprehend the inherent difference between the two.

To illustrate the matter, the generally accepted definitions for luminance and luminous emittance will be given and subsequently applied to an ideal emitter, that is, a uniform diffuser for which the luminance is the same in all directions irrespective of the direction of incidence of light. The emitter may be uniformly diffuse either by direct emission, transmission or reflection. Restriction to a uniform diffuser is not necessary, but serves to clarify the relation between luminance and luminous emittance without resorting to unnecessary mathematical complication.

The luminous flux emitted from a line spectrum source is given by

$$\phi = 680 \sum_{1}^{n} P_i v_i \qquad \text{lumens}$$

and that from a continuous spectrum source by

$$\phi = 680 \int P_\lambda v_\lambda d\lambda \qquad \text{lumens,}$$

the integration to be extended over the wavelength range corresponding to photopic vision. This takes care of the spectroradiometric aspect of radiation from luminous sources such as the above.

Based on the definition of luminous intensity in a given direction as the quotient of the luminous flux emitted by a source, or element of source, in an infinitesimal solid angle containing the given direction, by the solid angle, the luminous intensity may be written

$$I_\theta = \frac{d\phi}{d\omega} \tag{1}$$

where $$d\omega = \frac{dA_n}{r^2} = \frac{dA\cos\theta}{r^2} = f(r,\theta) \tag{2}$$

is the differential solid angle, in general a function of both r and θ. See Fig. 1.

The luminance L at a point on a surface in a given direction (a property of the luminous sur-

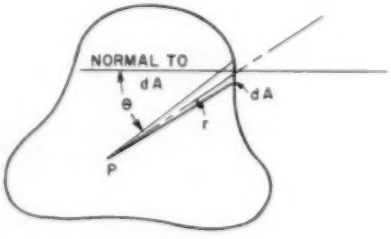

Figure 1.

AUTHOR: Department of Electrical Engineering, University of Michigan, Ann Arbor, Mich.

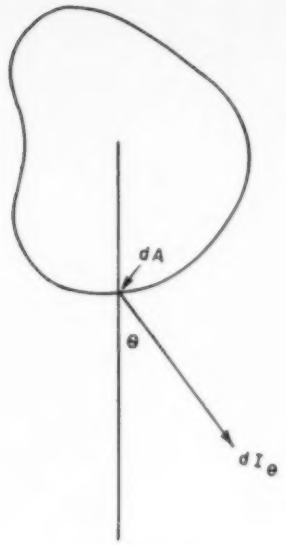

Figure 2.

face) is defined as the quotient of luminous intensity in the given direction of an infinitesimal element of the surface containing the point under consideration, by the orthogonally projected area of the element on a plane perpendicular to the given direction. Thus referring to Fig. 2,

$$L = \frac{dI_\theta}{dA\cos\theta} \tag{3}$$

In general both I_θ and L are variables for a finite source. Since

$$\frac{dI_\theta}{dA} = \frac{d^2\phi}{dA\,d\omega}$$

relation (3) may also be written

$$L = \frac{d^2\phi}{dA\cos\theta\,d\omega} \tag{4}$$

From (3) the luminance is defined as the intensity

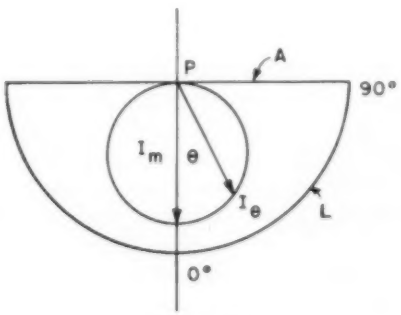

Figure 3.

per unit of projected area. For a finite surface the projected area is normal to the direction of viewing which amounts to the limiting condition of the source or any part of it treated as a point source.

The luminous emittance M from a point on a surface (a property of the luminous surface) is defined as the quotient of the luminous flux emitted from an infinitesimal element of surface containing the point under consideration, by the area of that element. Thus

$$M = \frac{d\phi}{dA} \tag{5}$$

From the definition of luminance L and luminous emittance M it is seen that the former is directional and specifies the ability of a luminous element to produce an effect at a given point in space (for example, illumination) whereas the latter specifies the flux-producing ability of a finite luminous emitter.

Since a uniform diffuser is one for which the luminance is the same in all directions irrespective of the direction of incident light, a surface element exhibiting this property would have luminance

$$L = \frac{dI_\theta}{dA\cos\theta} = \text{const.} \tag{6}$$

For a finite plane uniform diffuser luminous on one side as shown in Fig. 3 $L = \text{const.}$ implies that L is the same for all angles of observation for any element and for all elements of the plane surface as viewed from the luminous side. Thus the intensity I_θ must vary as the cosine of θ since the projected area also varies as $\cos\theta$. For this uniform diffuser

$$I_\theta = I_m\cos\theta \tag{7}$$

Since all differential elements of the area A lie in a plane for which θ is constant,

$$\frac{d\cos\theta}{dA} = 0$$

and

$$L = \frac{1}{\cos\theta}\cdot\frac{dI_\theta}{dA} = \frac{dI_m}{dA}$$

Thus for this case

$$L = \frac{I_m}{A} \tag{8}$$

The locus of intensity I_θ is a sphere tangent to the luminous surface at P with diameter equal to the intensity normal to the surface. The luminance L is constant and is represented by a hemisphere with center coinciding with point P.

The familiar relation $M = \frac{d\phi}{dA} = \pi L$ for a uni-

form diffuser, which establishes the invariant aspect of M for this type of emitter, may be found in textbooks on illumination. In general the derivations are based on the assumption that the uniformly diffusing element has a unique position on the luminous surface. Continuity of flux and divergence of the illumination field everywhere equal to zero will permit any position of the element on the luminous surface with the same net result. Thus there is no loss in generality. For a more general derivation consider the luminous element dA_s (L = const.) anywhere on the base of the hemisphere as shown in Fig. 4. Spherical coordinates are (θ', r, ψ). The governing relations are:

$$d\phi = dE\,dA_r \tag{9}$$

$$dA_r = r^2 \sin\theta'\,d\theta'\,d\psi \tag{10}$$

$$L = \text{const.} = \frac{dI_\theta}{dA_s \cos\theta} \tag{11}$$

$$dE = \frac{dI_\theta}{\rho^2}\cos\gamma \tag{12}$$

Since $r\cos\theta' = \rho\cos\theta$

$$\rho^2 = \frac{r^2\cos^2\theta'}{\cos^2\theta} \tag{13}$$

When the variables are substituted into Equation (9), the following expression is obtained for $d\phi$:

$$d\phi = \frac{L\,dA_s\cos^3\theta\cos\gamma\sin\theta'\,d\theta'\,d\psi}{\cos^2\theta'} \tag{14}$$

From solid analytical geometry

$$\cos^3\theta\cos\gamma = \frac{r^3\cos^3\theta'\,[r - d\sin\theta'\cos(\psi-\psi_d)]}{[r^2 - 2rd\sin\theta'\cos(\psi-\psi_d)+d^2]^2} \tag{15}$$

Substitution yields

$$d\phi' = L\,dA_s \left\{ \int_{\theta'=0}^{\pi/2} r^3\sin\theta'\cos\theta' \int_{\psi=0}^{2\pi} \frac{[r - d\sin\theta'\cos(\psi-\psi_d)]}{[r^2 - 2rd\sin\theta'\cos(\psi-\psi_d)+d^2]^2}\,d\psi\,d\theta' \right\} \tag{16}$$

The variables are θ' and ψ. Some initial simplification results from observing that cos $(\psi - \psi_d)$ is periodic in 2π, and since the integration with respect to ψ is over a complete period, ψ_d may have any value. If $\psi_d \equiv 0$, then the integration may be effected without loss in generality by appropriate change of variables and corresponding limits to obtain π as the result for integration with respect to both ψ and θ'. The result $d\phi'$ is the flux intercepted by the hemisphere due to the source element dA_s. Therefore

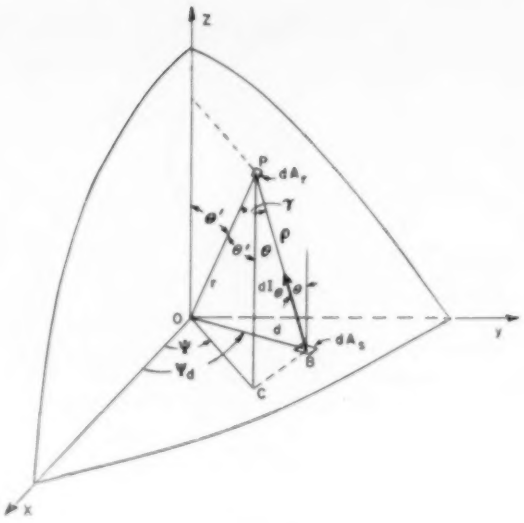

Figure 4.

$$M = \frac{d\phi'}{dA_s} = \pi L \tag{17}$$

Thus the luminous emittance M is constant for any given L. Equally important is the observation that M is a scalar point property of the luminous surface, every point on the surface exhibiting the same flux-producing ability. It follows that the luminous emittance concept cannot be applied to the finite luminous surface as a whole, that is, the surface may be referred to as having a luminosity M, but definition refers to a property at a point on the surface. In the general case M is a function of position of the element on the luminous surface. The above procedure may be extended to cover any

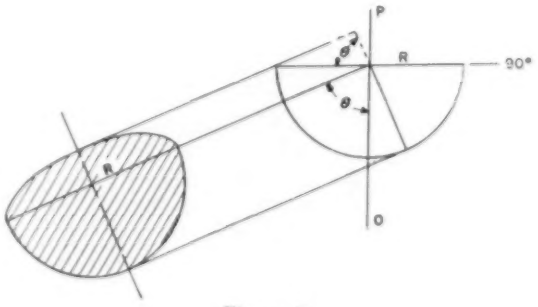

Figure 5.

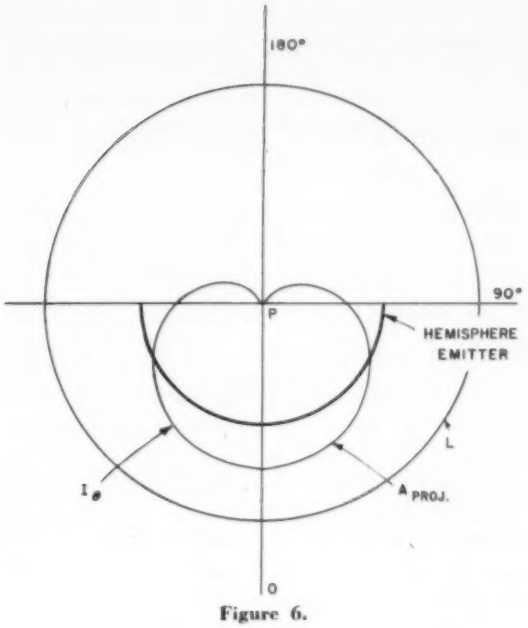

Figure 6.

curved surface of constant L to obtain the same result, although at the expenditure of considerable time and effort. A vector treatment would materially shorten the process.

Luminance control applied to a uniform diffuser may result in $M = kL$ where $k < \pi$. This may be accomplished by a sharp cut-off on the cosine luminance pattern at some angle less than $\pi/2$. Theoretically it is accomplished by appropriate change of limits of integration. Thus for $L = \text{const.}$ the following procedure is justified

$$\phi = \int M \, dA = \pi L A$$

where L is a directional property of the complete source and A is the actual area of luminous surface. In general, however, the luminous flux must be written as

$$\phi = \int M \, dA$$

A finite surface over which L varies with angle of observation or with position or with both angle and position does not subscribe to the relation $M = \pi L$. In such cases when the variation is pronounced, methods must be devised for determining its variation. A recent development in this direction involves an analogue computer for the predetermination of luminance patterns.

A relatively simple geometry involving a surface of assumed uniform luminance L is that of the hemisphere. It will better serve to illustrate how

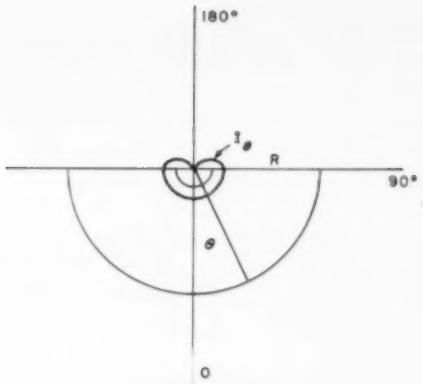

Figure 7.

an $L = \text{const.} \neq 0$ in any direction from a finite source is related to M and ϕ. In Fig. 5 the hemisphere of radius R has a constant L except for the base which is non-emitting. The projected area in the direction θ is

$$A_{proj.} = \frac{\pi R^2 \cos\theta}{2} + \frac{\pi R^2}{2} = \frac{\pi R^2}{2}(1+\cos\theta) \qquad (18)$$

It consists of the cross-hatched area comprised of a semi-ellipse and a semicircle of radius R. For $\theta >$ 90 degrees the projected area is the difference between the area of the semicircle and that of the semi-ellipse. If the intensities are defined through a constant L by

$$I_\theta = L A_{proj.} = \frac{\pi R^2 L}{2}(1+\cos\theta) \qquad (19)$$

then the locus of both $A_{proj.}$ and I_θ is a cardioid of revolution about the axis of symmetry OP. See Fig. 6.

Any part of or the total flux from this intensity distribution may be computed by the method of zonal constants, employing

$$\phi = \sum_0^n 2\pi I_{\theta_{mean}} (\cos\theta_n - \cos\theta_{n+1}) \qquad (20)$$

In the evaluation of flux from this source, it is well to consider that the distribution is that from a non-uniform point source, that is, the dimensions of the emitter are tentatively allowed to approach zero. See Fig. 7. $A\,\Delta M$ may be defined such that $\Delta M = \Delta\phi/\Delta A$ which, if evaluated for zonal increments on a non-absorbing non-diffusing hemispherical surface of radius R, varies from a maximum at $\theta = 0$ to zero at $\theta = \pi$. The maximum value of M is

$$\lim_{\theta \to 0} \Delta M = \lim_{\theta \to 0} I_{\theta_{mean}} \cdot \frac{\Delta\omega}{\Delta A}$$

$$\lim_{\theta \to 0} \Delta M = \lim_{\theta \to 0} \left\{ \frac{\pi R^2 L}{2} [1+\cos\theta_0+1+\cos\theta_{10}] \tfrac{1}{2} \cdot \frac{1}{R^2} \right\}$$

$$\lim_{\theta \to 0} \Delta M = \frac{\pi L}{4} \lim_{\theta \to 0} (2+\cos\theta_0+\cos\theta_{10}) = M = \pi L \quad (21)$$

The flux on a zone corresponding to θ is

$$\phi_\theta = \int_0^\theta I_\theta \, d\omega = \int_0^\theta \frac{\pi R^2 L}{2} (1+\cos\theta) \, d\omega$$

$$\omega = 2\pi (1-\cos\theta)$$

$$d\omega = 2\pi \sin\theta \, d\theta$$

$$\phi_\theta = \frac{\pi^2 R^2 L}{2} (3+\cos\theta) (1-\cos\theta) \quad (22)$$

in which $0 \leq \theta \leq \pi$ since I_θ exists for all values of θ from zero to π.

To simulate the problem under consideration, replace the hemispherical surface of radius R by a non-absorbing uniformly diffusing hemispherical globe of the same radius. Assuming no internal reflections within the material of the globe nor reflections from the inner surface thereof (equivalent of the globe as a primary emitter), this idealized hemisphere will redistribute the flux received according to the cosine law of emission. The flux in angle θ from (22) may be written

$$\phi_\theta = \pi L \left(\frac{3+\cos\theta}{4} \right) \cdot 2\pi R^2 (1-\cos\theta)$$

$$= \pi L' \cdot 2\pi R^2 (1-\cos\theta) \quad (23)$$

where $$L' = L \frac{3+\cos\theta}{4} = f(\theta)$$

To obtain the same flux in θ through a cosine distribution of intensity from the hemisphere of radius R, let L_x = const. represent the luminance of this hemispherical surface. This will ensure cosine variation of intensity on the surface of the hemisphere. Then the flux in angle θ is

$$\phi_\theta = \pi L_x \cdot 2\pi R^2 (1-\cos\theta) \quad (24)$$

Although the flux distributions given by (23) and (24) are different, for the same flux in the zone determined by θ these relations show that $L_x = L\,[(3+\cos\theta)/4]$ and for $\theta = 0$, $L_x = L'_{max} = L$, whence $M_x = M = \pi L$.

Thus the luminance L and the luminous emittance M for the uniformly diffusing hemisphere are respectively equal to the maximum values of these entities for the non-uniform point source distribution which was determined in (21). It should be noted that for the hemispherical globe both L and I_θ exist for all θ from zero to π, whereas M extends from zero to $\pi/2$. The above shows that the intensities of the uniformly diffuse hemisphere can be defined through an arbitrary L = constant through which L the flux emitted from any portion of the hemispherical area may be found from $\phi = MA = \pi LA$ where A is the area under consideration.

The flux emitted by a luminous surface is thus determined by its luminous emittance, which for a uniform diffuser is related to the constant luminance by a constant K. This constant is π when no part of the cosine emission is deleted through luminance control. Luminous emittance, furthermore, is a property of the surface and is not a directional entity regardless of whether the source is uniformly or non-uniformly diffusing. Luminance, on the other hand, is directional and may be applied to the source as a whole, irrespective of its diffusing characteristics.

Conference Preprints by Mail

Complete sets of the technical papers being presented at the 1959 IES National Technical Conference in San Francisco will be available by mail order from the IES Publications Office, as usual. These will not be available before the Conference, but orders may be placed at any time for mailing in September. Order coupon was on page 6A of the June issue of IE.

Evaluation of Direct Discomfort Glare In Lighting Installations

Report No. 6 of the Committee on Standards of Quantity and Quality for Interior Illumination of the Illuminating Engineering Society

FOREWORD

This report represents a compilation of available data on discomfort glare. It is the result of seven years' work by the Committee on Standards of Quality and Quantity for Interior Illumination.*

COMMITTEE ON STANDARDS OF QUALITY AND QUANTITY FOR INTERIOR ILLUMINATION

Glenn A. Fry, *Chairman*

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1. Introduction

(a) A portion of the 1944 report[1] of this Committee dealt with discomfort glare. The criterion for discomfort glare used in that report was that of momentary shock experienced when one quickly looks up from his work and looks directly at a bright luminaire. The present report differs from the earlier one in that it deals with the case where the subject does not fixate on any of the light sources, but looks casually about the room, with his direction of view approximately level or at least not more than five degrees above the horizontal. The subject may have just previously been looking down at his work, or his eyes may have been in the raised position for some time. Today's dissatisfaction with poor or mediocre lighting installations seems to originate most frequently under circumstances such as these.

(b) This Committee has, therefore, undertaken the admittedly difficult task of formulating a glare evaluation system, applicable to various lighting installations, when experienced under the conditions just outlined. Several systems of evaluation have been devised by members of this Society; namely, that proposed by Harrison and Meaker,[2,3] that by Luckiesh and Guth,[4] and that by Logan and Lange.[5]

(c) That by Luckiesh and Guth is generally accepted as evaluating the sensation of discomfort caused by single light sources located in any position in the field of view. However, experience has shown that the presence of several light sources in one's visual field may give rise to a condition of marked discomfort, when any one of the sources alone would have been found innocuous. The problem has been to provide a method by which the effect of individual sources may be summated. At this time there is not sufficient information available to afford a solution on a thoroughly scientific and satisfactory basis, and the recommendations which are made by this Committee today may be subject to considerable revision later on when all the factors are known. However, there is a pressing need at the present time for some reasonable system of evaluation and the Committee regards it as the Society's responsibility to offer the best guidance that it can based on information now available. Provisions against glare which deal solely with luminaire brightness are not regarded by the Committee as adequate or equitable.

(d) It is the considered opinion of this Committee that the greatest promise of a solution to the evaluation of multiple light sources lies in the direction of adding luminaire areas after they have been brought to some common basis. One way that this has been done is by establishing a glare rating for each source and then adding the glare ratings.[2,3] In another method the individual sources of different areas and brightness have been converted to equivalent sources of all the same brightness and the areas added directly.[5] Various technical objections have been voiced against both of these systems. The Committee now recommends a

*The functions of this Committee have since been largely delegated to the Committee on Recommendations for Quality and Quantity of Illumination.

Approved by the Council of the Illuminating Engineering Society, June 1957. A Transaction of the IES.

summation, which it believes answers most previous criticisms.

(e) In attempting to formulate a glare evaluation system for the Society, the Committee has concentrated on amalgamating the methods originating in this country. However, the Committee wishes to acknowledge the contributions which have been made in other countries. The studies in other countries have been reviewed by Guth,[6] and attention is also called to the 1955 Report of the CIE Committee on Estimation of Comfort in Lighting.[7]

2. Aim

It is the aim of this report to define a basis for rating the capacity of a luminous environment to produce discomfort. Specific standardized procedures for evaluating existing environments and those in the process of being designed must be presented in subsequent reports.

3. Environments Covered by this Report

It is not possible to rate all luminous environments by the system about to be described. The special difficulties encountered with various types of environments will be discussed in other parts of this report.

4. General Statement of the Recommended Procedure

First of all one evaluates the individual sources separately by computing for each a discomfort factor, and then the discomfort factors for these individual sources are added to obtain a discomfort factor for the group of sources in a given environment. This establishes a means of relative appraisal of different environments. The problem of deciding when a given area of brightness constitutes a glare source will be discussed later.

5. The Discomfort Factor of an Individual Glare Source

The discomfort factor G of a given glare source is defined by this Committee as a function of four variables:

B, the brightness of the source (footlamberts);
ω, the solid angle subtended by the source (steradians);*
P, the position index, and
F, the field brightness (footlamberts).

*It is also possible to express solid angle in terms of per cent of the visual field and it is usually assumed that the visual field is equal to five steradians. Thus one per cent of the visual field is equal to $^1/_{20}$ of a steradian, or one steradian is equal to 20 per cent of the field of view.

6. The Field Brightness

(a) The assessment of the discomfort factor G is based upon data obtained with a source momentarily superimposed upon a uniform field covering the entire visual field. When the environment involved contains all kinds of non-uniformities it is necessary to entertain a great deal of reservation about applying the data and it becomes very difficult to assess the field brightness, F. When a value is assigned to F this means that the source is treated as having the same capacity for producing discomfort as if it were presented on a uniform background covering the rest of the field of view and having a brightness equal to the assigned value of F.

(b) It is advantageous to be able to evaluate a given glare source for any position of the eye and direction of regard and, indeed, such evaluations can be made. However, for practical purposes it may be necessary to limit consideration to typical locations and orientations of the eyes. A thoroughgoing analysis would even have to take into consideration the immediate past history of the eyes at the moment for which the evaluation is made. A typical situation in which glare would be encountered is one in which we start with the eyes turned down 60 degrees to a page of printed matter lying flat on a desk and then the eyes turn upward to view an object at eye-level. In this situation the portion of the retina exposed to the glare sources (luminaires) when the eyes turn up will have been adapted to the part of the field that corresponds to the top part of the printed page. In this instance the average brightness of the printed page may be used for F.

(c) One can also evaluate the discomfort produced by turning the eyes up from the printed page and looking directly at a luminaire. In this case the average brightness of the printed page also may be used for F.

(d) One could also consider the case in which the eyes steadily fixate a point at eye level at the far end of the room. In this case, the value for F should probably be the average brightness of the region of the glare sources. Further, it might appear that data obtained with sources momentarily exposed would not apply, but fortunately it has been demonstrated[8] that in such a situation a steady exposure and a momentary exposure yield approximately the same discomfort rating.

(e) There is no simple solution to this problem. In a situation where it is not possible to make a more adequate evaluation of F, it may be assumed to be equal to the illumination E at the point of observation on a plane perpendicular to the direc-

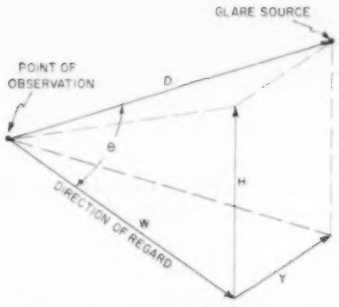


Figure 1. (above). Method of specifying the location of a glare source in the visual field.

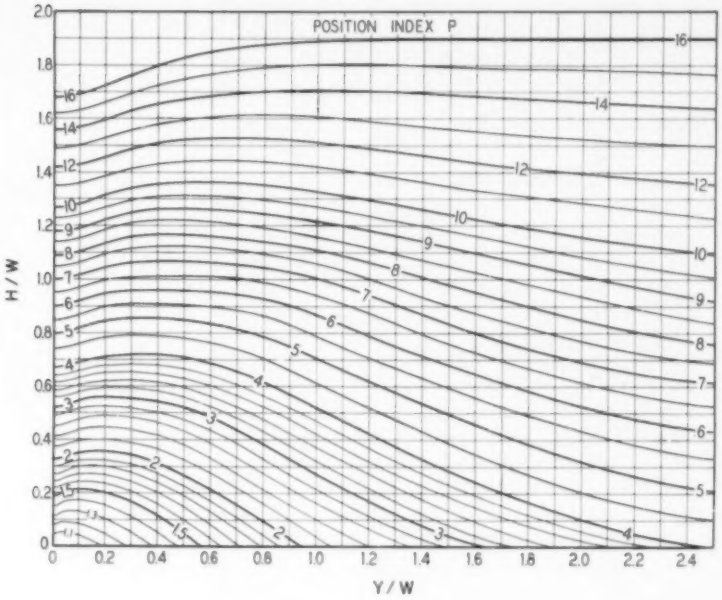


Figure 2. (right). Chart for determining the position index *P* from *H*, *Y* and *W*.

tion of regard. In the case of a uniform field of brightness, E will be equal to the average brightness expressed in footlamberts. When the field is non-uniform it is to be expected that the value of E may not correspond to the average brightness.

7. The Position Index

(a) The position index P makes an allowance for the angular displacement θ of the glare source from the direction of regard. As shown in Fig. 1 the position of the glare source can be specified in terms of Y, H, and W. The center of this coordinate system is located at the midpoint of the base line connecting the centers of rotation of the two eyes. The line connecting this point with the point of fixation is the W axis, and the plane containing the fixation point and the centers of rotation is the W, Y plane. The H axis is perpendicular to the W, Y plane. The position index P which is based on the data reported by Luckiesh and Guth[4] can be obtained from the graph of Fig. 2.

(b) In illuminating engineering it is common practice to describe an observer as having a point of observation and a fixation point. The line connecting these two points is called the line of sight. For the purpose of this report we can identify the point of observation as the midpoint of the base line and the W axis as the line of sight. However, in the field of physiological optics, the W axis is designated as the median line, and the observer is said to have two lines of sight (one for each eye) which connect the center of each entrance pupil and the point of fixation. The brightness, B, of the glare source divided by the position index, P, gives the brightness of a glare source of the same angular subtense on the line of sight which will produce an equivalent amount of discomfort. The original data apply to the case of fixation straight ahead. Strictly speaking a certain amount of error is introduced by using these data when the eyes are turned to the right, left, up or down without corresponding movement of the head because of the interference from the nose, eyebrows and eyelashes.

8. The Solid Angle Subtended by the Glare Source

The solid angle subtended by the glare source is represented by ω in steradians and may be computed in accordance with the following equation:

$$\omega = \frac{A}{144\,D^2} = \frac{A}{144\,(H^2 + W^2 + Y^2)} \qquad (1)$$

where D = the distance of the glare source in feet,
A = the projected area of the glare source in square inches,
H = the displacement of the glare source above the plane of regard (W, Y plane) in feet,
W = the distance in feet from the midpoint of the base line to the plane through the glare source which is normal to the line of sight, and
Y = the lateral displacement from the H, W plane in feet.

The relationship among D, H, Y and W is shown in Fig. 1.

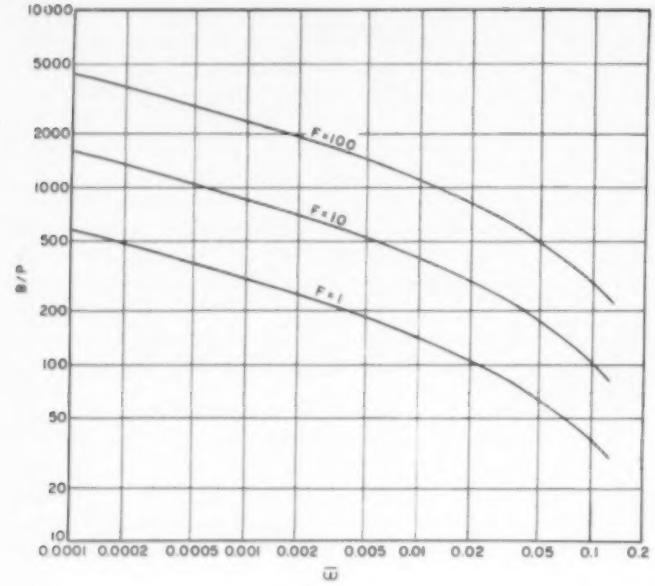


Figure 3. (left). The relationship of $\bar{\omega}$ to B/P and F.

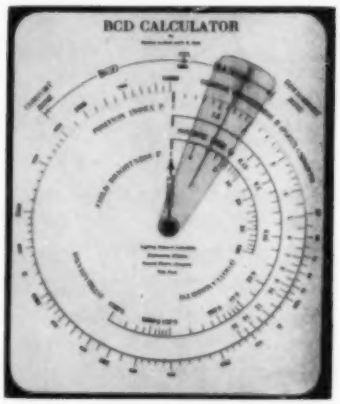


Figure 4. (above). Slide rule for computing $\bar{\omega}$ for a single source.

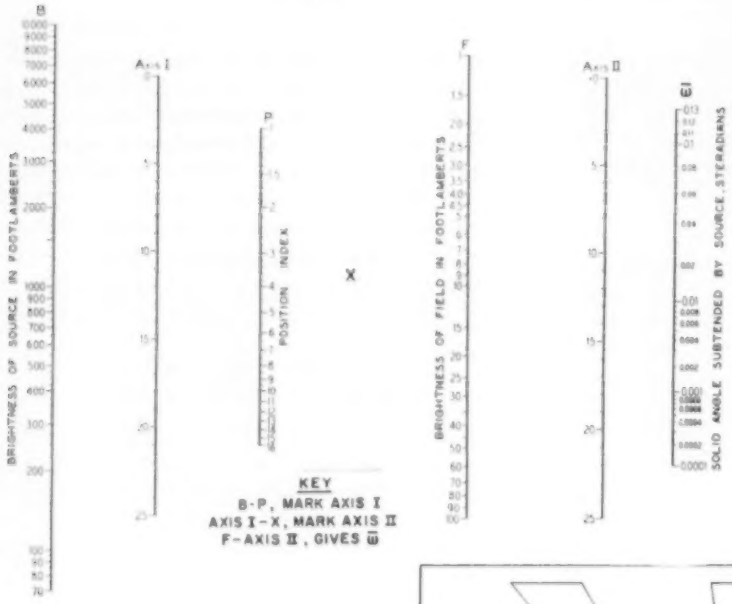


Figure 5. (left). Nomogram for computing $\bar{\omega}$ for a single source.

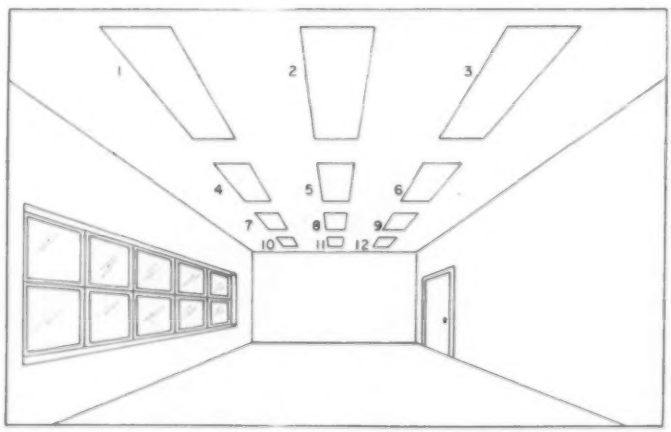


Figure 6. (right). Typical luminous environment for illustrating the method of evaluating discomfort glare.

9. The Brightness of the Glare Source

The average brightness (footlamberts) of the glare source is represented by B and may be defined as follows:

$$B = \pi E/\omega \qquad (2)$$

where E is the illumination (footcandles) produced by the source at the point of observation on a plane normal to the direction of the source.

10. The Discomfort Factor Equation for a Single Source

(a) The discomfort factor G is defined as follows:

$$G = \frac{\omega}{\bar{\omega}} \qquad (3)$$

where

$$\bar{\omega} = \left[\frac{B/P}{108\,F^{0.44}} + 1.28 \right]^{-4.76} \qquad (4)$$

(b) The value of $\bar{\omega}$ can be determined from the graph in Fig. 3 and represents the size of a glare source for a given set of values of (B/P) and F which lies at the borderline between comfort and discomfort. The nomogram in Fig. 4 or the slide rule in Fig. 5 may also be used for computing $\bar{\omega}$.

11. The Discomfort Factor for a Number of Glare Sources

(a) It is recommended that the discomfort factor for a number of glare sources can be determined simply by adding the discomfort factors of the individual glare sources in accordance with the following formula:

$$G = G_1 + G_2 \ldots + G_n. \qquad (5)$$

The justification for this procedure has been discussed at length by Fry.[9]

(b) Fig. 6 represents a view of a given luminous environment from the point of observation. The point of fixation is at the far wall and all luminaires shown would be in the normal field of view. The value of F measured at the point of observation is equal to 30 footlamberts. The areas treated as glare sources are designated by numerals. In columns 2 to 7 of Table I values of the physical characteristics are tabulated. From this information values of $\bar{\omega}$ (column 8) can be determined and finally the values of G (column 9) can be computed. The sum of the G values for the separate sources is recorded at the bottom of column 9 as the discomfort factor of the complete system.

(c) When the sources are scattered in the visual field as is usually the case, one can hardly expect the value of G computed from Equation (5) to agree perfectly with the value determined experimentally. It is not known how to make an allowance for the distribution of scattered sources with respect to each other and with respect to the line of sight. Luckiesh and Guth[4,10] have demonstrated that such discrepancies exist. It follows therefore that Equation (5) ought to be construed merely as a means for the comparative rating of two environments and not as a measure of the amount of discomfort produced.

12. Small Glare Sources

(a) Equation (4) cannot hold for small glare sources which approximate point sources. For such sources the effect of changing area must be exactly equivalent to that of changing brightness. On the basis of the work of Putnam and Faucett,[11] Logan and Lange[5] have deduced the following relation between $\bar{\omega}$ and B for small sources on the line of sight and on a uniform background of one footlambert:

$$B = \frac{0.00367}{\bar{\omega}} \qquad (6)$$

We may write a general equation as follows,

$$B = \frac{108\,P\,F^{0.44}(1 - 1.28\bar{\omega}^{0.21})\,(.000034 + \bar{\omega}^{0.79})}{\bar{\omega}} \qquad (7)$$

TABLE I — Example of the Computation of the Discomfort Factor for the Lighting System Shown in Fig. 6.

1	2	3	4	5	6	7	8	9
Luminaire No.	B (footlamberts)	H (feet)	Y (feet)	W (feet)	P	ω (steradians)	$\bar{\omega}$ (steradians)	G
1	500	6	7	8	5.0	0.0160	0.160	0.10
2	560	6	0	8	4.6	0.0290	0.130	0.22
3	500	6	7	8	5.0	0.0160	0.160	0.10
4	450	6	7	14	2.6	0.0062	0.095	0.06
5	470	6	0	14	2.5	0.0082	0.086	0.10
6	450	6	7	14	2.6	0.0062	0.095	0.06
7	400	6	7	20	1.92	0.0027	0.077	0.04
8	400	6	0	20	1.90	0.0032	0.076	0.04
9	400	6	7	20	1.92	0.0027	0.077	0.04
10	380	6	7	26	1.62	0.0014	0.066	0.02
11	380	6	0	26	1.64	0.0015	0.067	0.02
12	380	6	7	26	1.62	0.0014	0.066	0.02

Discomfort Factor of Complete System = 0.82

which covers the range of $\bar{\omega}$ values from 0 to 0.12 steradian. This reduces to

$$B = 108\, P\, F^{0.44}\, (\bar{\omega}^{-0.21} - 1.28) \qquad (8)$$

for values of $\bar{\omega}$ (0.0001 to 0.12) covered by the Luckiesh-Guth data and reduces to

$$B = \frac{0.00367\, P\, F^{0.44}}{\bar{\omega}} \qquad (9)$$

for small values of $\bar{\omega}$ (*i.e.*, values lower than 0.000001).

(b) Most of the sources with which we are concerned in connection with the present problem fall within the range covered by Equation (8) which is identical with Equation (4).

(c) It should be pointed out in connection with small sources that in some instances values for the product of B and $\bar{\omega}$ can be assessed when separate values for these two quantities cannot be assessed. It should also be noted that

$$\frac{B\omega}{\pi} = E = \frac{I}{D^2}$$

where E represents the illumination at the eye on a surface normal to the direction of the source and is measured in footcandles, I represents the luminous intensity of the source in candles and D represents the distance of the eye from the source in feet.

13. Limitations of this Report

(a) We are faced first of all with the limitations imposed by the data used in evaluating $\bar{\omega}$. We are limited in the range of F values from 1 to 100 footlamberts. Also the range of ω values extends only up to 0.12 steradian. It is not safe to extrapolate beyond these limits.

(b) One easy mistake to make is to say that if a glare source of 0.12 steradian produces discomfort, making it larger would always make it more uncomfortable, but if we made it large enough to cover the entire field of view, it would constitute nothing more than a uniform field and the brightness might have to be increased considerably to make it uncomfortable.

(c) Although previous investigators[2,12] have called attention to the "buffering" action of the immediate background of a glare source, no allowance for this factor has been included in the system of glare rating described in this report. The nature of the problem is illustrated in Fig. 7. *A* represents a glare source, *B* the immediate background and *C* a surround. Under the system described in this report *B* can be treated as a glare source or as part of the field. In the first case it makes the discomfort factor *G* larger but in the latter case it makes *G* smaller by increasing the value of field brightness *F*. The problem is even more complicated when the transition from *B* to *C* or from *A* to *B* is graded.

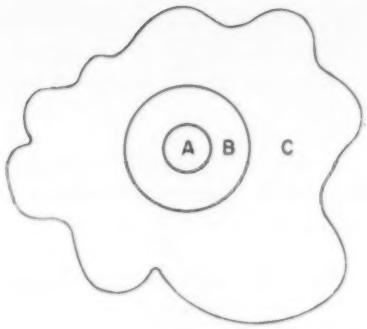


Figure 7. Illustrating the problem of brightness grading from one zone to another.

(d) When the system described in this report is applied to this kind of situation the results must be interpreted with a great deal of reservation.

14. Anticipated Subsequent Refinements

Finally it must be emphasized that this report is tentative. The Committee believes that new data will lead to a more precise method of evaluating *F* and the roles played by eye movements and the brightness of the immediate background. It is also to be expected that the method of evaluating multiple glare sources will have to be refined and improved upon as more data become available.

References

1. Committee on Standards of Quality and Quantity for Interior Illumination of the Illuminating Engineering Society: Report No. 1, "Brightness and Brightness Ratios," ILLUMINATING ENGINEERING, Vol. XXXIX, No. 10, p. 713 (December 1944).
2. Harrison, Ward: "Glare Ratings," ILLUMINATING ENGINEERING, Vol. XL, No. 8, p. 525 (September 1945).
3. Harrison, W., and Meaker, P.: "Further Data on Glare Ratings," ILLUMINATING ENGINEERING, Vol. XLII, No. 2, p. 153 (February 1947).
4. Luckiesh, M., and Guth, S. K.: "Brightnesses in Visual Field at Borderline Between Comfort and Discomfort (BCD)," ILLUMINATING ENGINEERING, Vol. XLIV, No. 11, p. 650 (November 1949).
5. Logan, H. L., and Lange, A. W.: "The Evaluation of Visual Comfort Data," ILLUMINATING ENGINEERING, Vol. XLVII, No. 4, p. 195 (April 1952).
6. Guth, S. K.: "Quality of Lighting," ILLUMINATING ENGINEERING, Vol. L, No. 6, p. 279 (June 1955).
7. National Secretariat Committee, Australia: Report 3.1.1.2, "Estimation of Comfort in Lighting," *Proceedings of the International Commission on Illumination*, Zurich, Vol. I (1955).
8. Guth, S. K.: "Comfortable Brightness Relationships for Critical and Casual Seeing," ILLUMINATING ENGINEERING, Vol. XLVI, No. 2, p. 65 (February 1951).
9. Fry, G. A.: "Evaluation of Discomfort Glare," ILLUMINATING ENGINEERING, Vol. LI, No. 11, p. 722 (November 1956).
10. Guth, S. K.: "Subjective Additivity of Areas of Brightness," *Proceedings of the International Commission on Illumination*, Zurich, Vol. I (June 1955).
11. Putnam, R. C., and Faucett, R. E.: "The Threshold of Discomfort Glare at Low Adaptation Levels," ILLUMINATING ENGINEERING, Vol. XLVI, No. 10, p. 505 (October 1951).
12. Petherbridge, P., and Hopkinson, R. G.: "Discomfort Glare and the Lighting of Buildings," *Transactions of the Illuminating Engineering Society (London)*, Vol. XV, No. 2, p. 39 (1950).

Views and Opinions

Electrical Aspects of Lighting to New Levels

In discussing factors involved in increasing illumination levels to meet current IES recommendations for industry, a consulting engineer brings up aspects of electrical distribution systems, lighting vs power rates for electricity, costs of added components, air-conditioning factors—how these can affect or be affected by re-lighting to the new levels.

There is no doubt that the new recommended lighting levels in industry are "Just what the doctor ordered" when applied in the proper manner. There are, however, some aspects other than those of a strictly illuminating engineering nature which must be considered. These are factors of practical "cost discomforture" in electrical systems, which must be taken into account when relighting for the new levels is being planned.

To relate lighting to these factors, we must begin with the data shown in Table I, which shows the watts per square foot introduced by various levels of general illumination with some of the most common light sources. In it, I have not considered current developments which are being made to increase output of various gas discharge light sources by boosting frequency.

A study of the recently recommended general illumination levels leads me to believe that we can settle on an average figure of 75 footcandles as the increase in general level recommended for industrial tasks. The table shows that 75 footcandles are nowhere available for less than 3.21 watts per square foot, and this is based on very favorable conditions. I should like to assume a figure of 4 watts per square foot as a more conservative figure on which to base our thinking. If additional lighting loads could be considered from the standpoint of the electrical distribution system as a strictly additive feature, (that is, if it required independent electrical distribution installations as for a new building containing only the added lighting), we could orient our thoughts regarding initial costs by budgeting a distribution system supplying 4 watts per square foot to an industrial space, of say 200 feet by 300 feet, with a service installation in one corner. I have studied just such a case and have developed the following per square foot cost figures for the electrical distribution system up to the lighting fixtures. For the instance where electrical energy is supplied at 120/208 volts, 3-phase, 4-wire into the building, I come up with 55¢ per square foot. For the case where this voltage system is desired and the service is supplied at a primary voltage level, the figure is 64¢ per square foot. For the usually more economical secondary voltage level of 277/480 volts, 3-phase, 4-wire supplied directly to the building, it is 42¢ per square foot. And for a secondary system having these latter voltage char-

TABLE I — Relation of Illumination Levels to Electrical Energy Dissipation.

General Description	Specific Example: Lamp Type	Specific Example: Lamp Watts	Average Lumen Output During Lamp Life	Total Watts Dissipated (Lamp Ballast Loss*)	Maintenance and Space Conditions	Watts per Square Foot for Various Illumination Levels: 25 fc	50 fc	75 fc	100 fc	150 fc	200 fc
Mercury Vapor	H1LS	400	16,200	428	Good	1.47	2.94	4.41	5.88	8.82	11.80
					Poor	3.34	6.68	10.00	13.40	20.00	26.70
Mercury Fluorescent	H1LB	400	15,000	426	Good	1.58	3.16	4.74	6.32	9.48	12.64
					Poor	3.58	7.16	10.70	14.30	21.50	28.60
Slimline Fluorescent 425 ma	96-inch T12 cool white	74	4,500	87	Good	1.07	2.14	3.21	4.28	6.47	8.56
					Poor	2.43	4.86	7.29	9.72	14.60	19.40
Rapid-Start Fluorescent	48-inch T12 cool white	40	2,350	47	Good	1.11	2.22	3.33	4.44	6.66	8.88
					Poor	2.52	5.04	7.56	10.10	15.10	20.20
High-Output Fluorescent	96-inch T12 cool white	105	6,500	127	Good	1.08	2.16	3.24	4.32	6.48	8.64
					Poor	2.46	4.92	7.38	9.84	14.80	19.70
Extra-High Output Fluorescent	96-inch PG17 cool white	200	11,500	228	Good	1.10	2.20	3.30	4.40	6.60	8.80
					Poor	2.50	5.00	7.50	10.00	15.00	20.00
General Line Fluorescent	48-inch T12 cool white	40	2,350	49	Good	1.17	2.34	3.51	4.68	7.02	9.36
					Poor	2.66	5.32	7.98	10.60	16.00	21.30
Incandescent	IF PS35	300	5,000	300	Good	3.34	6.68	10.00	13.40	20.00	26.70
					Poor	7.55	15.10	22.70	30.20	45.30	60.40

*Represents ½ loss of 2-lamp ballast where applicable.

acteristics where primary voltage is supplied to the building, the figure is 54¢ per square foot. In the same line of rough thinking as has been used to establish initial cost figures, we might also assume that electrical energy could be purchased fairly cheaply for increased lighting, because additive amounts of electrical energy can usually be bought at lower incremental cost than the initial quantities.

Let us now look at some of the factors which require us to re-evaluate the conclusion-jumping we have been doing up to now. Revised lighting plans in most cases require some abandonment and replacement of existing lighting circuiting and the introduction of entirely new circuiting. Revised lighting layouts imply such new items as new outlet locations to assure even distribution of lighting output from added and existing light sources, as well as revised switching and control to tie in with existing or newly established lighting control schemes. It is easy to understand why abandonment and readjustment of existing work, as well as new work, is always involved. Almost without fail, it turns out that the aggregate cost of partial new circuiting to cover an over-all new lighting scheme is more than that of new circuiting introduced strictly on the basis of the additional watts per square foot.

Another factor upsets our initial rough approach to the subject. If electric power is supplied by a utility company at a secondary utilization voltage level, the user of the electricity must usually use a single radial system: that is, one feed point distribution system on his property. Netting two or more secondary services together is virtually taboo, because utilities generally do not wish to depend on the consumer to maintain proper connections and protector devices necessary to (1) balance loads through utility company transformers, (2) inhibit feed-back into faults on utility lines, and (3) maintain system stability where more than one power plant is involved. Introduction of two or more secondary radial systems into a single property, unless absolutely essential for utility company capacity development, is also frowned upon. Utility companies do not wish to become involved in doing distribution work which is not strictly part of the function of a supplier of electrical energy. They feel that if they are called upon to introduce a separate service every time additional capacity is required on a property they would probably be performing part of the distribution work which the user of the electricity should be doing himself.

Utility companies inhibit the use of multiple radial systems by refusing to combine meter readings on two or more meters measuring the consumption of a single user. In this way, they curtail the quantity purchase benefits which could accrue under most of their rate schedules. Code authorities, concerned with the ease with which electrical systems can be de-energized when fires or accidents occur, also prefer a single radial system on a property to permit control by a single service switch. All this boils down to the fact that, on secondary distribution emanating from a utility company supply at a utilization voltage level, additional load usually cannot be tied in with equipment sized for and assigned to the additional load exclusively. Procedures for abandonment of existing equipment in exchange for new and larger equipment sized for the over-all load —existing plus new—are then necessary. On such secondary services where a great amount of copper is involved, such procedures of abandonment can really put the bite on.

The same ground rules as mentioned for secondary services apply also to primary voltage services. However, in the case of primary voltage services we can usually anticipate some redeeming features. Since insulation, and not copper, is usually the factor tending to introduce cost into the handling of primary voltages, we can anticipate (with our fingers crossed, perhaps) that existing service connections and service receiving switchgear has not been skimped, so far as capacity is concerned, at least not as much as on secondary services. This means, of course, that tapping off the existing switchgear to supply additional load without interfering with incoming line switches, etc., is a distinct possibility where primary services are concerned. It must be remembered, however, that as indicated in our rough cost figures transformers must be purchased for the additional load—this expense being one which is not involved when dealing with the secondary services. In many industrial installations the radial primary system emanating from the utility company service is connected into a secondary network system owned and maintained by the user of the electricity. This system, of course, does not involve the utility in any problems arising from feedback into faults, etc. However, it may create some difficulty in connection with the problem of additional load. Network systems are intended to provide firm capacity for industrial sites, where loss of electricity may mean heavy production losses during times of failure of individual items of distribution equipment and their associated connections. It may be quite possible to add increased load on a network system without overloading any of its elements, but its ability to stand

up during times of equipment failure will probably be affected. To add load to a network system and still have it reflect the same firmness in capacity delivery as initially intended may be an extremely expensive proposition.

A third fact to plague us when we add load to a distribution system has to do with short circuit capabilities. Except in those rare cases where improved cooling of electrical equipment permits it to stand up under increased loading without damage or excessive drop in output voltage, increased load obviously means increased capacity required in distribution components. Increased capacity in distribution components generally means reduced impedance between the load point and the generating point, and reduced impedance means heavier currents fed into short circuits when they occur. In simpler terms, distribution elements which conduct current to the load more effectively under normal conditions also conduct currents better into short circuits. This reasoning is not as rigorous as it should be, but probably will suffice for the present purposes.

This increased short circuit capability presents quite a problem. Since, as has been stated, we are more than likely to be increasing capacity on single radial or network systems, not only are the distribution components for the added load subjected to heavier short circuits, but also the existing components may be tied in on a circuit where short circuit capabilities are greater than that for which they were originally designed. What this really means is that circuif breakers feeding existing loads may have to be changed to be able to to interrupt greater short circuits. Bussing and switchboards may need stronger bracing than originally furnished. Re-fusing with current-limiting fuses, to implement the action of existing circuit breakers, may be required. All this, of course, adds up to additional expense which has nothing to do with the cost of the equipment required merely to feed the added load.

A final fact in connection with side expenses which added load can introduce is in connection with the optimistic idea introduced earlier of purchasing electrical energy for added load at an advantageous rate. Although there are many utility company rate schedules which support this idea, quite a few others favor power loads (motor and heating) over lighting loads. When new lighting is added we may find that the rate schedule says that, by exceeding a certain maximum allowance of electrical consumption for lighting, we lose a discount that can be applied to our entire bill for electricity. Also, since it is a continuous load, general lighting can be expected to ride on the top of maximum demand peaks. There are quite a few rate schedules which penalize our entire ability to purchase electricity for all purposes when the maximum demand reading on our meter goes up.

So far we have discussed existing distribution systems which are not adequate for the lighting load which we desire to add. Let us look for a moment at the industrial plant where the switchboard is running nice and cool, the service equipment seems very large compared with the current values computed from the demand meter readings and where, in fact, every forethought seems to have been given toward electrical expansion. In such a situation we are ready to congratulate ourselves and start placing orders for new lighting fixtures, panelboards, etc., in preparation for the development of the new lighting we desire. But before this, however, let us look at the switchboard again; in most cases, we will find that every switch or circuit breaker is connected. In each case, an expensive plug-in bus duct feeder installation is tied into the switch, either immediately or, in large installations, on the load end of a low-x bus feeder. This means that a large expense has been borne to assure adequate capacity for increased production, not for increased lighting. General lighting, which is usually a fixed load, does not warrant the expensive procedure of being supplied through plug-in bus duct installations. So before the spare capacity can be used for increased lighting, we must find out if it really is available for added lighting. If business is good, the answer is most likely "no." Even if the answer is "yes" it is not feasible to use the plug-in bus duct feeders as distribution elements for the new lighting installation, for sooner or later a large motor in connection with production would get on the same bus duct with the lighting. The only thing that seems to restrain production people from creating frequent and sizable voltage dips on their feeders is the drop-out point of motor starting holding coils. For general lighting, since lamp flicker is involved, less than 5 per cent is recommended.

Up to now, I do not think I have been remiss in concentrating on the application of the new lighting loads to existing distribution systems. The industries for which the new levels have been published are not new and have major capital investment in existing plants. I think that when the merits of the higher lighting levels have been proven to the people who have to pay for them, they will not wait for new building programs to put them into effect. They will, instead, attempt to improve production from their present installations by introducing the recommended lighting,

thereby throwing the burden on existing distribution systems.

Even where new buildings and new distribution systems are concerned, however, some of the problems of existing systems still persist. From the standpoint of what the situation would be without new levels, although there is no question of abandonment of existing equipment, there may well be factors over and above the addition of components to handle the increased lighting load. Interrupting capacities may have to be stepped up for overcurrent protection devices throughout the entire system. Rate schedule problems will exist as previously described, and so forth.

Perhaps, here, a word should be said about supplementary lighting. Unlike general lighting levels, supplementary lighting levels do not lend themselves to generalizations as to distribution systems. They are, of course, associated with particular work surfaces and machines. To the extent that industrial operations manage to replace obsolete production machines with new machines, in many cases of larger capacity, without any rehabilitation of their electrical distribution system requiring over-all capacity increase, it is conceivable that confined increases in supplementary lighting can be applied with relatively small effort. In any case it is hard to compute any watts per square foot figure for supplementary lighting to draw general conclusions regarding electrical distribution systems. A study of each specific instance involving this subject is required.

It is gratifying to see that there are definite programs afoot working toward the acquisition of more light energy from each unit of electric energy expended. Our most efficient light sources are capable of converting only about 15 per cent of the electrical energy fed into them into visible light energy. These days when much of our electro-mechanical energy conversion takes place at efficiencies exceeding 90 per cent, there is hope in knowing that our best research brains are looking toward similar, less wasteful conversion of electrical energy into light energy. Increasing the efficiency of light sources is no easy task, and present-day efforts utilizing frequency boosting have resulted in an 8 to 12 per cent increase based on the capabilities of conventional 60-cycle systems. This, though spectacular in itself, represents at best only 12 per cent of 15 per cent, or less than 2 per cent in the over-all picture of energy conversion. When thinking in terms of large jumps in illumination levels, 2 per cent does not appear to be very significant.

A few more painful thoughts. Capacity added or increased electrical distribution components require additional space. And many industrial processes require spaces with temperature and humidity control, let alone comfort air-conditioning. In industrial plants, where access to process piping, etc., is essential, procedures such as exhausting heat from lighting fixtures in plenums above suspended ceilings, before it is dissipated in the critical area below, are rarely practical. And what will added refrigerations and air-handling loads then do to our electrical distribution systems?—Mark Eitingon, *Eitingon & Schlossberg Associates, Consulting Engineers, New York, N. Y.*

IES Lighting Data Sheets and The New Footcandle Recommendations

In June 1958, a new set of footcandle recommendations was adopted by the Illuminating Engineering Society. The new values, in most cases, are considerably higher than the superseded ones. This means that many of the IES Lighting Data Sheets published before June 1958 report installations that do not meet present IES recommended practice, as to *footcandles on the task*.

It should be recognized, however, that the footcandle level provided is only one of several considerations that determine the quality and all-around adequacy of an installation, and its suitability for recording in an IES Lighting Data Sheet. Visual comfort, brightness ratios and the inherent appropriateness of the lighting system to the lighting application are equally important factors.

It is suggested, therefore, that IES Lighting Data Sheets issued before June 1958 may still be used with confidence as a guide to good lighting practice so far as lighting techniques are concerned. To determine whether the footcandle values indicated meet present recommendations, consult the footcandle tables published in the August 1958 issue of Illuminating Engineering and supplemented in the February 1959 issue, or in the Third Edition, *IES Lighting Handbook*.

Subcommittee on Lighting Data Sheets
Publications Committee

Here and There with IES Members

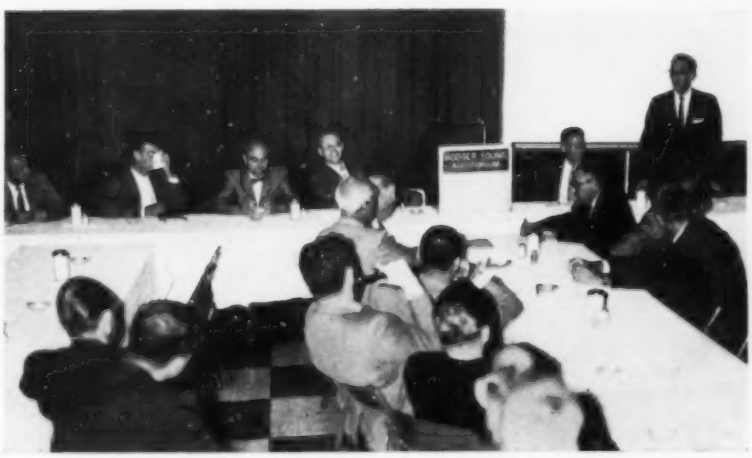
Winner of the Allied Arts competition sponsored by the Arizona Section of IES was Ronald Wonsley, of Arizona State University in Tempe. Here J. D. Whitnell, Chairman of the Section's Allied Arts Committee, presents the check for the award. Mr. Wonsley's design will be shown at the IES National Technical Conference in San Francisco, Calif., this September.

A total of 139 years of membership in IES is represented by the three members of the proposed new East Bay Section, shown here with President George Taylor. L. to r.: H. H. Robison, 41 years; Mr. Taylor; Romaine Myers, 45 years; Charter Member James Cravath, 53 years. The East Bay group held its fifth meeting May 18 in Oakland, Calif., with Grant Radford, Chairman.

MMILJ winners in the St. Louis Section were, l. to r.: Ed Thias and William Simms in Class II and Dorothy Davis in Class I, here receiving their checks from Section Chairman Charles Zurheide.

Dinner meeting of the Southern California Section May 6 featured Dan Finch as speaker. Left to right in photo are Frank Lee, Section Chairman; Benn Hartmann, Vice-Chairman, and Prof. Finch.

Preceding the dinner meeting of the Southern California Section on May 6, the Section's study club heard a panel of experts discuss the facets of achieving a good lighting installation. Left to right are: Jim Grant, Study Club Chairman; Les Rothstein, electrical contractor; Gale Thomas, manufacturer; Rene Marxheimer, session Chairman; Herbert Wollman, electrical engineer, and Jules Salkin, architect.



MMILJ, Toronto Section. Photo at right shows judges making their decisions on the winners who are shown below. Left to right are Grant Davidson, Margaret Lidstone, John Chorlton, and Carl Wilson, Canadian Regional V-P.

Winners in the Toronto MMILJ contest with Section chairman are: l. to r., F. Reed, first in Class I; M. K. Strang, first in Class II; E. Machtinger, chairman; F. Collins, honorable mention; Gwen Butterworth, second in Class I; Ron Mathews, honorable mention; R. E. McCormick, second in Class II; Jack Townsend, honorable mention.

Smorgasbord and dance at Vasa Lund Park is the occasion. Winnipeg Chapter holds their annual meeting. At the head table, l. to r.: D. E. MacPherson, Mrs. MacPherson, Mrs. G. J. Nowell, G. J. Nowell, Mrs. F. Dehod, E. T. Battle, F. Dehod, Mrs. E. T. Battle, A. A. Bertrand, Mrs. Bertrand, and H. Gottlieb, a guest from Montreal. Absent is Chairman A. C. Burnard who was attending the Pacific Northwest Regional Conference in Banff.

Garden Lighting was the subject of an outstanding meeting of the San Diego Section, May 14. Speaker was William Shalda, who used the setting of Balboa Park as an example. Attendance of 250 attests to the success, with people from all section of the industry and building and garden groups attending. Credit goes to Section Chairman Ralph W. Rohrbach, E. L. Peterson, R. O. Gray, W. J. Beran and A. J. McCutcheon, among others.

LIGHTING NEWS

North Texas Section Host to Southwestern Regional Conference

Nothing, it seems, can faze a Texan. Although now citizens of only our second-largest state, IES members in San Jacinto produced a regional conference, second to none—in imagination, professional finesse, technical program and the added touches which helped to make it the success it was. The meeting took place at the Shamrock-Hilton Hotel, Houston.

Pre-convention activities included a trip down the Houston ship channel on the new Sam Houston yacht, as far as the San Jacinto Monument and battleground where the battleship Texas is permanently anchored. This unusual introduction to a regional conference took place Sunday morning before registration. An alternative activity, for landlubbers, was golf at the Lake Forest Golf Club.

Other Sunday events, May 3, were registration during the afternoon and a Local Activities Meeting. The President's reception, in honor of Mr. and Mrs. Taylor, was the highlight of the evening, with entertainment by the 35-member Humble Glee Club, who gave a thirty-minute program of regional and national songs. This group is composed of employees of the Humble Oil & Refining Co. who sing just for the pleasure of it.

MMILJ Contest

Always one of the most popular features of a conference, the MMILJ Contest was put on the program of the first day of technical sessions. It followed a welcome to the city of Houston by the Honorable Lewis Cutrer, Mayor, to which John B. Deck, Jr., Regional Vice-President, responded. Elmer L. Cole, Chairman of the North Texas Section, was chairman of the session, to which the entire morning was devoted. Winners of the contest were:

Class I—Residential

First—Miss Mary Wallace, Texas Power & Light Co., Dallas, North Texas Section, with her entry "Lighting a Speculative Builder Home"

Second — Mrs. Virginia Benson, Central Power & Light Co., Sinton, Coastal Bend Chapter, for "Glamorizing a Country Home."

Third—Jack Huddleston, Frey-Huddleston & Associates, Shreveport, La., with "Lighting the Circular Home of Dr. and Mrs. E. B. Flake.

Class II—Commercial and Industrial

First—Don Copeland, Crouse-Hinds Co., Houston, San Jacinto Section, "Lighting a Paper Mill."

Second—Harold G. Samuels, Texas Power and Light Co., Dallas, North Texas Section, "First Baptist Church of Waco."

Third — Floyd Covington, City Public Service Board, San Antonio, Alamo Section, "Lighting a Horseshoe Riverbend Park."

National President George J. Taylor was speaker at the luncheon which followed; Conference Chairman George L. McGonigle presided.

Technical Program

A complete listing of the topics and speakers will be found at the end of this report. Here, suffice it to say that the general theme was on topics of great con-

Pleasure and real joy is shown by winners of MMILJ contest as President Taylor makes the awards. Happy smile in photo at left is that of Miss Mary Wallace, winner in Class I. In photo at right, Don Copeland, winner of the Class II contest, is congratulated by the IES President. Presentation took place during the banquet.

President George Taylor and Mrs. Taylor smile in appreciation of the unusual gift, an original oil painting of the Southwest, painted for them by Chester Snowden, nationally famous Texan artist. The gift was from the San Jacinto Section, whose Chairman, George H. Simpson, is also smiling because Mr. Taylor said "I had expected another Western hat, which would have been No. 10 in my collection."

cern to lighting engineers—the aspects of the new IES recommended levels, new developments in home lighting, and researches being conducted on vision. A top-notch group of nationally known speakers presented the papers.

Special Events

A variety of special events distinguished this conference. Complete coverage by newspapers and the appearance of President Taylor and Miss Myrtle Fahsbender on television station KGUL did much to make Texas aware of IES. Mr. Taylor was interviewed on the Mark Noble early morning show and Miss Fahsbender appeared on Woman's World Show. She was also interviewed by *The Houston Post* and *The Houston Chronicle* for articles to appear after the convention.

Lothrop Gavel. This award, given in memory of Reuben K. Lothrop, deceased regional vice-president from Shreveport, La., was fittingly enough won by the Ark-La-Tex Chapter whose headquarters are in that city. This award, an innovation not anticipated by regional members, was given for the group having the most members in attendance from the greatest distance.

Dinner Dance. This social event was most successful, with 180 present to enjoy the music by Albino Torres and the act of Zaney Blaney.

Gift to Mr. and Mrs. Prexy. Presentation of a gift to Mr. and Mrs. Taylor caused much pleasure for all. Typical of the imagination shown by these conference planners was the originality of the present. Mr. Taylor, who expected a western-style hat, was thrilled by receiving an original oil painting of a scene near Elgin, Texas. The artist was Chester Snowden, a native Texan who has exhibited his work in the United States and South America and has two paintings in the D. D. Feldman Collection of 100 most famous Texan paintings.

Ladies Activities—In addition to the social activities in which all participated, the women had a program especially for them. This included a lecture on "Charm and Comportment" by Mrs. Billye Moore of the Houston John Robert Powers Studio, and a luncheon and style show at Sakowitz' famous Sky Terrace. Shopping and/or sight seeing trips occupied their afternoons. They were also free to attend the technical session at which Miss Myrtle Fahsbender of Westinghouse spoke on "Flexibility—Today's Trend in Home Lighting."

Where Credit Is Due

As with all well-managed events, a great deal of hard work and planning is required for a polished performance. Credit for the Southwestern Regional Conference goes to many IES members under the leadership of these committees.

General Conference Committee

John B. Deck, Jr., Regional Vice-President

General Chairman	George L. McGonigle
Vice-Chairman	Harry G. Hrivnatz
Secretary	Richard C. Jung
Treasurer	Wayne Toudouze

(*Continued on page* 10A)

IES President George Taylor on camera, appearing on the Mark Noble early morning show over KGUL Channel 11. Miss Myrtle Fahsbender also appeared on television later that day.

FAIRVIEW

SPECIFIED BY THE WORLD'S FINEST ENGINEERS

DAY-BRITE LIGHTING, INCORPORATED
ST. LOUIS 15, MO., SANTA CLARA, CALIF.

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Planners: In photo at left, Richard C. Jung, Secretary; George L. McGonigle, General Chairman; and Harry G. Hrivnatz, Program Chairman, are in the usual order. In photo at right are Mrs. Merrill C. Wright and Mrs. Chambers A. Patterson, Chairmen of the Ladies Committee, with Sumner Harris, Entertainment Committee Chairman.

(Continued from page 8A)

Committee Chairmen

Attendance and Publicity	George H. Simpson
Entertainment	Sumner Harris
Hotel	Bill Sneed
Ladies	Mrs. Merrill Wright, Mrs. C. A. Patterson
M.M.I.L.J. Contest	Don L. Copeland
Lighting and Decorations	C. A. Patterson
Transportation	Arthur M. Rice
Program	H. G. Hrivnatz

Chapter and Section Chairmen

Richard W. Barnes—Chairman, Alamo Section
M. W. Perkins—Chairman, Ark-La-Tex Chapter
Williams S. Irving—Chairman, Central Oklahoma Chapter
B. L. Guess, Jr. — Chairman, Coastal Bend Chapter
Elmer L. Cole—Chairman, North Texas Section
James C. Netherton, Jr.—Chairman, Oil Capital Section
Harold W. Powell — Chairman, Panhandle Chapter
George H. Simpson — Chairman, San Jacinto Section
Arthur C. Waghorne—Chairman, South Plains Chapter

Miss Myrtle Fahsbender, one of the nationally-known speakers.

Conference Program

Sunday, May 3

Golf—at Lake Forest Golf Club
Boat Trip
Local Activities Meeting
President's Reception

Monday, May 4, Morning

Conference Opened by John B. Deck, Jr., Southwestern Regional Vice-President
Welcome to City of Houston—The Honorable Lewis Cutrer, Mayor of Houston
Response—John B. Deck, Jr.
"My Most Interesting Lighting Job"—Session Chairman, Elmer L. Cole, Chairman, North Texas Section.
Luncheon—Chairman, George L. McGonigle
Address—George J. Taylor, National President I.E.S.

Monday Afternoon

Session Chairman—M. H. Perkins, Chairman, Ark-La-Tex Chapter
Light Sources and Their Applications—Ted C. Sargent, Sylvania Electric Products Inc.
Quantity and Quality Requirements of Lighting—John J. Neidhart, The Miller Co.
Lighting Concepts Today and Tomorrow—R. T. Dorsey, General Electric Co.

Monday Evening

Dinner Dance—Chairman, George H. Simpson

Tuesday, May 5

Session Chairman—Richard W. Barnes, Chairman, Alamo Section
Flexibility—Today's Trend in Home Lighting—Miss Myrtle Fahsbender, Westinghouse Electric Corp.
The Lighting of Space for Living — C. L. Crouch, I.E.S. Technical Director
Area Lighting with Mercury Lamps—Howard W. Stentz, Wide-Lite Co.
Ballasts in Lighting applications — E. C. Pauly, Ballast Division, General Electric Co.

(*News continued on page* 13A)

Address Changes should be reported to IES Headquarters by the first of any month, to insure the uninterrupted mailing of IE and other Society communications.

Dex (Managing Director) Hinckley with R. T. Dorsey, speaker at the Monday afternoon session.

Klondike

by PERFECLITE

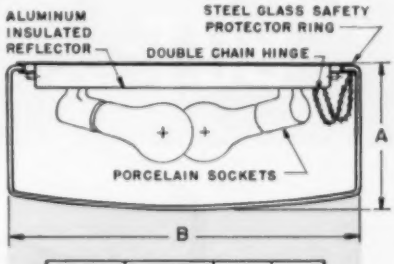
- **FLUSH TO CEILING**
- **BUILT-IN LOOK**
- **ALL GLASS**
- **ALL LIGHT**

No metal shows, nothing projects on the Klondike*, Perfeclite's latest incandescent ceiling unit. Mounted absolutely flush, it allows maximum utilization of the opal globe for the highest light efficiency available . . . gives that built-in look without costly recessing.

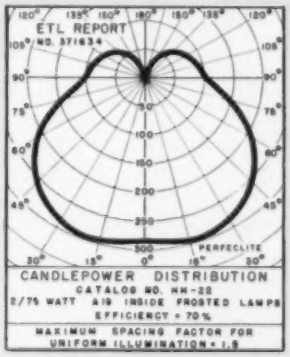
The globe opens on a double chain hinge for quick, easy cleaning and relamping . . . is secured in place again with a simple twist of the wrist by a unique patented locking device. Interior construction is of 20-gauge steel. The reflector is faced aluminum. The multiple porcelain sockets are equipped with #18 A F leads for direct connection to Types R, TW or any 60° C rated wire.

Here at last is a totally new concept in fixture design . . . a totally new way to provide better lighting for either commercial or residential interiors. For further information, mail the attached coupon today!

Units are Underwriters' Laboratories, Inc., approved.



Cat. No.	Wattage	A	B
HH-21	2-60W	5⅛"	10"
HH-22	2-75W	5⅝"	12"
HH-23	2-100W	6⅛"	14"
HH-24	3-100W	6⅝"	16"



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They LOOK alike...

BUT...

Two stones may look alike, making it difficult to decide which one is the diamond. So it is with lighting standards. Two steel standards may look the same, but only Kerrigan standards have these plus values:

1. Superior strength, with stronger bracket connections
2. Heavier wall thickness (.130)
3. More resistance to bending—less deflection
4. Drop forged steel anchor base
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6. Guaranteed high yield point
7. One continuous longitudinal weld—Magnafluxed
8. Octagon shape—Inherently stronger than the round or fluted
9. Trim, modern lines, architecturally correct

NEW from KERRIGAN — THE CLASSIC Pat. Pending

Send for FREE catalogs on steel and aluminum standards—Address: Dept. I-7

Weldforged LIGHTING STANDARD DIVISION

KERRIGAN IRON WORKS, INC.

Nashville, Tennessee

Technical Program and Fun Stressed at Midwestern Regional

Advance publicity sent out to IES members listed "28 reasons why you should attend the 1959 Midwestern Regional Conference, Peoria, Illinois, May 6, 7, 8." These reasons included the fact that Peoria is the site of the world's largest distillery and is the earthmoving center of the world. But the attendance of 205 who flocked to the Pere Marquette Hotel were probably more attracted by the excellent technical program and the gaiety of the social events. Central Illinois Chapter was host and arranged a well-rounded program with pleasure and profit for all.

Scheduled to begin on May 7, the conference jumped the gun with a pre-registration party in the Carrousel Room, which was decorated to resemble a night club of the Roaring Twenties. Food, drink and atmosphere recalled the days of flapper girls and derby hats.

Technical Program

Serious business began on Thursday morning. Following the invocation by Rabbi Joseph L. Ginsberg, a welcome by Councilman Ray Neumann for Peoria's Mayor Eugene Leiter and a brief report by Midwestern Regional V-P Brooks Chassaing, the program continued with the MMILJ contest. There were entries in both classifications, and the winners who received their awards later at the President's Dinner Dance Thursday evening, were:

Class I—Residential

First — Mrs. Elsie Claiborne, Milwaukee Section, Wisconsin Electric Power Co., Milwaukee, Wis.

Second — Miss Dorothy Davis, St. Louis Section, Illinois Power Co., Granite City, Ill.

Third—Donald Olson, Twin City Section.

Class II—Commercial and Industrial

First—Neil J. Thompson, Heart of America Section, Kansas Power & Light Co., Topeka.

Second—Lowell R. Berg, Chicago Section, General Electric Co., Chicago.

Third—E. H. Schaefer, Milwaukee Section, Wisconsin Electric Power Co., Milwaukee.

Harold Young, of Peoria, was Regional Contest Chairman.

Theme of the remaining technical sessions was on the problems encountered by the higher levels of illumination now being recommended. Papers and speakers are listed at the end of this report.

Social Program

For the women attending, in addition to the Roaring Twenties Party and the Dinner Dance, social activities included a luncheon and skit at the Country Club of Peoria on Thursday and luncheon at Vonachen's Junction, one of the city's most popular eating places. Cologne was given as a favor to each lady.

The President's Dinner Dance, in honor of Mr. and Mrs. Taylor, was the highlight of the social activities. Leisurely dining with dancing between courses gave members and their wives from all over the Region a chance to become better acquainted and exchange ideas.

Special events occurring at the dinner-dance included the presentation of its Charter to the Central Kansas Chapter. This was done by Regional Vice-President Brooks Chassaing. On a more personal note, a presentation was made to President Taylor by the host Central Il-

(*Continued on page* 14A)

Provocative speaker John Marshall Ziv, who raised the question "Are we lumen engineers or seeing engineers?"

Midwestern Regional Conference was officially opened with addresses by Regional Vice-President Brooks Chassaing, left, and Conference Chairman M. R. Weiman.

Desk set—a gift from the Central Illinois Chapter—is admired by President and Mrs. Taylor as Director J. A. Schneller, left, smiles his agreement.

MMILJ Awards — Harold Young, contest chairman, at right in both photos, presents certificates and checks to Regional winners. In photo at left, M. H. Bruesewitz, Chairman of the Milwaukee Section, accepts the award for the prize-winning installation of Mrs. Elsie Claiborne in Class I; in photo at right, Neil J. Thompson, Heart of America Section, is congratulated for taking first place in Class II—Commercial and Industrial.

(Continued from page 13A)

linois Chapter—a gift of a pen-perpetual calendar desk set, both useful and decorative. The MMILJ awards were also made at the dinner.

CREDITS

Responsible for the success of this well-rounded conference are Regional V-P Brooks Chassaing, Conference Chairman M. Richard Weiman, Secretary Robert B. Hovind, Treasurer Delwin N. Schneider and the following committee chairmen:

James W. Brown—Papers and Program
Orlo Oberlander—Social and Hotel
William Tometich—Registration and Reception
Charles E. Carter and Earl Lyle—Attendance and Publicity
Robert Zucker—Decorations and Display
James Orr and Kenneth Jacob—Transportation
Doris McCutchen—Ladies
Harold Young—MMILJ Contest

CONFERENCE PROGRAM

Wednesday Evening, May 6

Pre-Registration Party

Thursday Morning, May 7

Opening Session—Presiding Chairman, M. R. Weiman, Chairman Midwest Regional Conference
Invocation—Rabbi Joseph L. Ginsberg
Welcome to Peoria from Honorable Eugene Leiter, Mayor of Peoria.
My Most Interesting Lighting Job Contest—Harold Young, Midwest Regional Conference Chairman
Noon—Buffet Luncheon

Thursday Afternoon

President's Address—George J. Taylor, President of I. E. S.
Introduction—D. N. Schneider, Chairman, Central Illinois Chapter.
Economics of Higher Footcandles—E. A. Lindsay, General Electric Co., Cleveland, Ohio.
Introduction—Charles H. Zurheide, Chairman, St. Louis Section
Does More Light Mean Better Lighting?—W. V. C. Foulks, Curtis Lighting, Inc., Chicago, Ill.

Thursday Evening

President's Dinner Dance — M. R. Weiman, Chairman
Presentation of MMILJ Contest Awards—Harold Young, Regional Contest Chairman.

Friday Morning, May 8

Local Activities Meeting—Brooks Chassaing, Regional Vice-President, Presiding.
Color for High Level Lighting—John Marshall Ziv, Color Consultant, Chicago, Ill.
Introduction: F. T. Tillemans, Chairman, Twin City Section
Maintenance for Lighting Systems—Mel Galbraith, Approved Lighting Service, Cedar Rapids, Iowa.
Introduction: E. W. Schoenherr, Chairman, Iowa Section.
Color and Cosine Corrected Light Measuring Instruments — Carl Miller, Weston Instruments Division of Daystrom, Inc.
Introduction: M. H. Bruesewitz, Chairman, Milwaukee Section.

Friday Afternoon

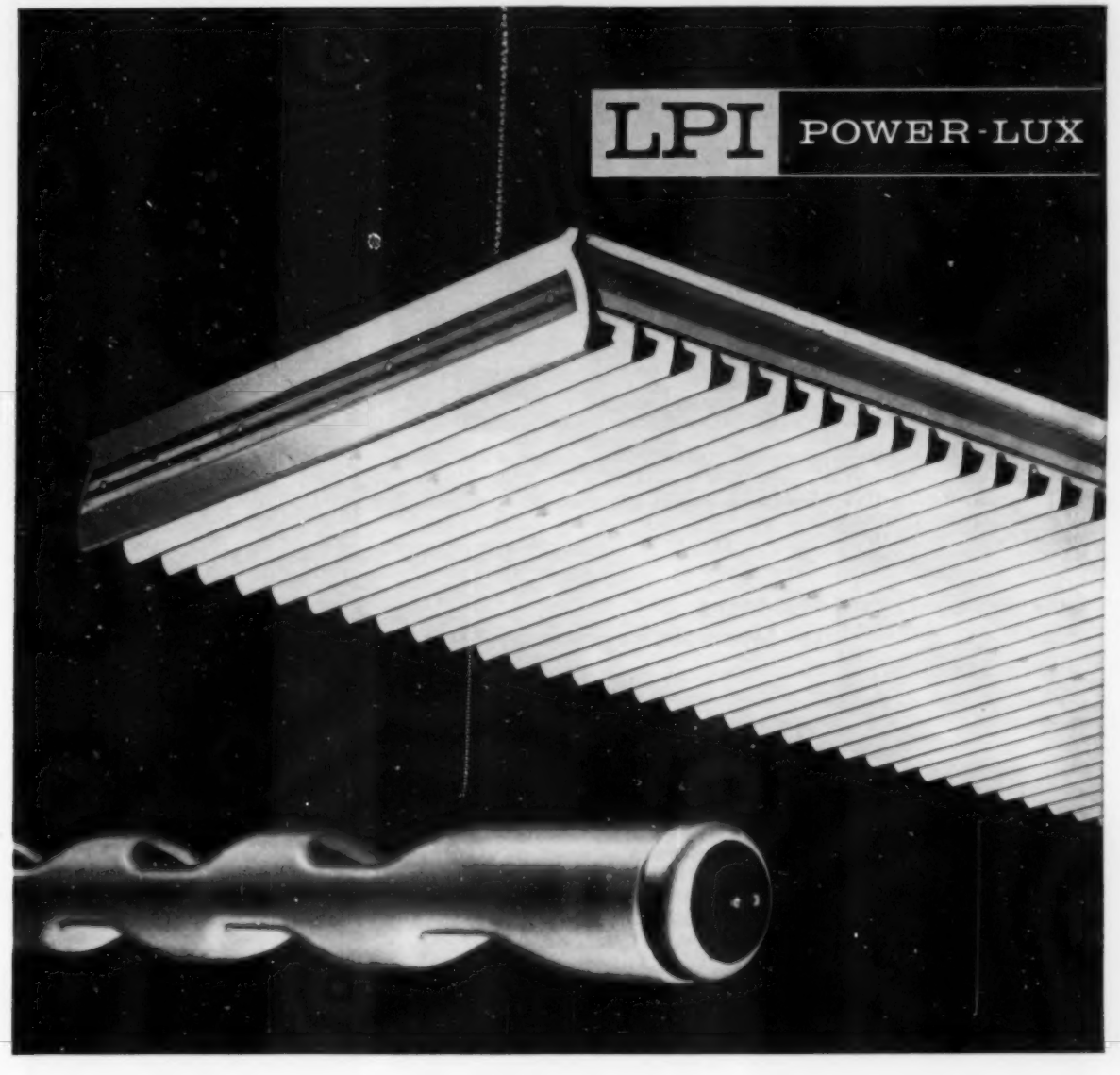
Parade of Progress—E. A. Lindsay, General Electric Company, Cleveland, Ohio.
Conference Adjournment

Looking ahead to 1960—members of the Cornhusker Section met in Sioux City on April 17 to make plans for next year's Midwestern Regional. Seated, left to right: C. R. Tracy, Co-Chairman; Brooks Chassaing, Regional V-P; J. R. Chambers, IES General Secretary; Mark E. Lee, Co-Chairman.

Residence Lighting Forum Organized in Toronto

The Residence Lighting Forum Committee of IES is pleased to announce the formation of a Forum in Toronto, Ont., making a total of 13 such affiliate groups in the United States and Canada. Officers of the new Forum are: Chairman, Russell Cresswell; Vice-Chairman, Peggy Lidstone; Secretary, Gwen Butterworth; Treasurer, Bill Smith.

(News continued on page 16A)



60,000 lumens at 80-percent efficiency

LPI Power-Lux luminaire gives stores over 200 footcandles with Power Groove lamps, is engineered for comfortable brightness

A specially designed luminaire now lets you light stores with improved Power Groove lamps. Manufactured by Lighting Products Inc., Power-Lux incorporates special engineering features which provide 80-percent efficiency. Exclusive parabolic louvres control 60,000-lumen output of four Power Groove lamps, providing high-level illumination at comfortable brightness.

One economical Power-Lux with Power Groove lamps does the job of three ordinary slimline fixtures.

Power-Lux is an outstanding choice for new stores as well as for raising lighting levels of existing commercial buildings. In re-lighting applications, the new luminaire simply replaces present fixtures to give dramatic increases in illumination.

Power-Lux is available in four-lamp models, 36 inches wide; and in two-lamp models, 12 inches wide. Both are supplied in four and eight-foot lengths. **For complete information write for LPI's Power-Lux Bulletin.**

Lighting Products Inc. Highland Park, Illinois

LPI FLUORESCENT LIGHTING

Facial foliage was cultivated by sincere sons of Colorado, in honor of their state's Centennial being celebrated this year. Left to right, they are: C. D. Bell, Dick Auer, Carl Balsick, Dick Jones, James Parker, Bill Stultz, F. A. Schoor.

Colorado Centennial Heightens Inter-Mountain Regional Conference

Tieing in with the "Rush to the Rockies Centennial" which is being celebrated in Colorado this year, the Inter-Mountain Region of IES did some looking back at their conference, in Denver May 11 and 12. The frontier spirit was hirsutely cultivated by some Colorado patriots (see photo) and, in a more serious vein, the Keynote Address, by Harold Rankin, reviewed the history of lighting in the Denver area. Otherwise the program concentrated on the latest in lighting, including predictions for the future.

Technical Sessions

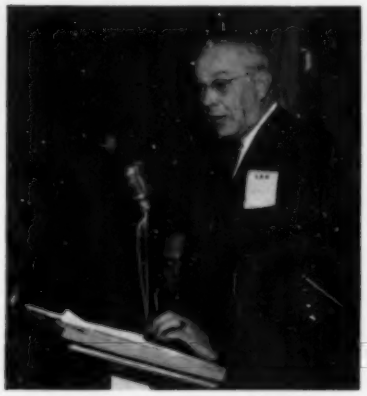
Technical sessions, which were held at the Continental-Denver Hotel, ranged in topic from papers on vision requirements, new sources and equipment to a tour of the Martin plant—where the Cape Canaveral missiles are manufactured and tested. This tour was, of course, a highly unusual event for the delegates, since the missiles tested there are in condition to go off if not nailed down.

Less exciting, but of great interest, was the always popular contest for My Most Interesting Lighting Job. Top winners were: Class I, Mrs. Vivian Hamilton, New Mexico Chapter, and Class II, Fred Rosenquist of the Rocky Mountain Section.

Entertainment

The Tuesday evening dinner-dance was, naturally, enjoyed by all, and in addition a most interesting program was provided for the ladies. A tour of the city with luncheon at the Columbine Country Club and a talk on the centennial by Mr. Milton Bernet, of the Colorado Centennial Commission, occupied a good part of one day. And a tour of Red Rocks Park, the Magic Mountain, Lookout Mountain and the Buffalo Bill Museum filled another. The Magic Mountain project is a frontier-type park being built in the mountains west of Denver, by the same people who

(*Continued on page* 19A)

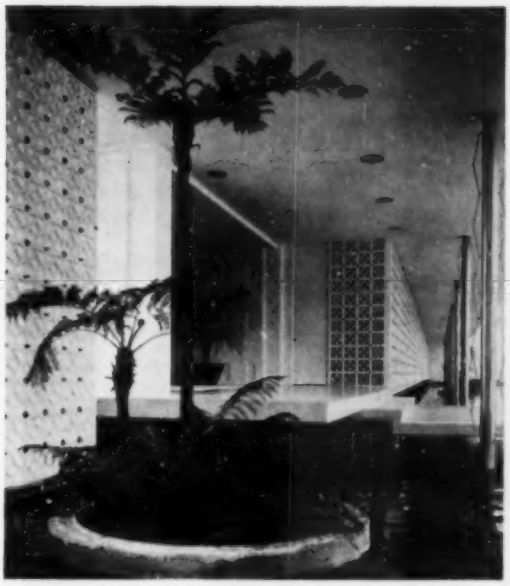


Harold Rankin, who gave the Keynote Address at the opening session.

IES Gold Medalist Prof. J. O. Kraehenbuehl was luncheon speaker on May 11.

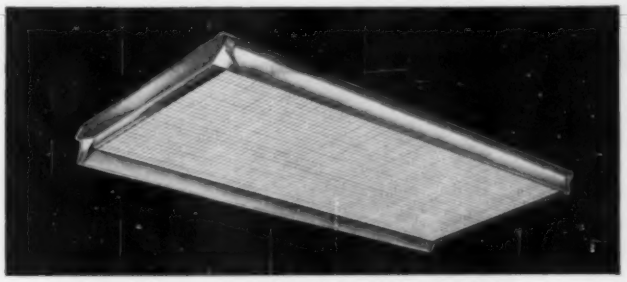
Class I winner, MMILJ, was Mrs. Vivian Hamilton.

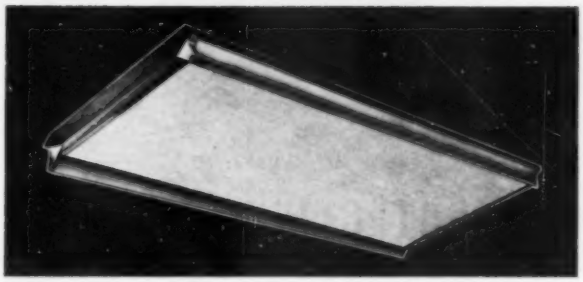
Class II winner, MMILJ, was Fred Rosenquist.



For Architecture and Sculpture in lighting specify the –

SCULPTURAMA
THE SCULPTURED LOOK IN LIGHTING



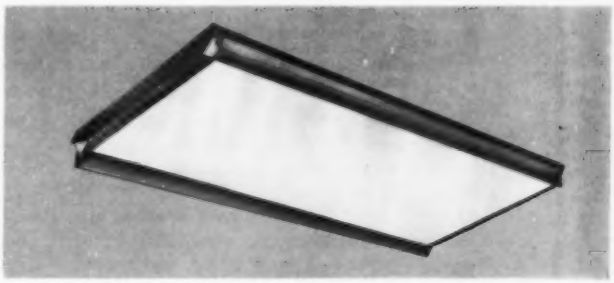


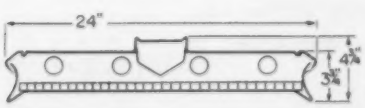
QPLM7500 with miniature-celled plastic louver shielding

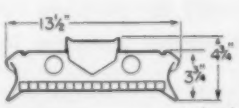
QPCX7500 with SUNLUX; *clear optically sharp plastic lens panel*

QCA7500 with translucent white Albalite glass diffuser

SCULPTURAMA, the Sunbeam Lighting Company's #7500 series Visionaire®, has the refinement in design and the sculptured look which fuses itself with today's architecture. Shallow in appearance, it forms a surface mounted, "area" source of pleasant, low-brightness illumination. All-metal sides are gently curved and are illuminated with interflected light to reduce fixture-to-ceiling contrasts. The sturdily framed single-element diffuser opens from either side on continuous "hook-on" hinges and may be completely removed without use of tools. For maximum versatility, SCULPTURAMA is available in a wide range of diffusing mediums, including SUNLUX, for 2 or 4 rapid start lamps and for single or continuous row installation. Write for bulletin #A84c

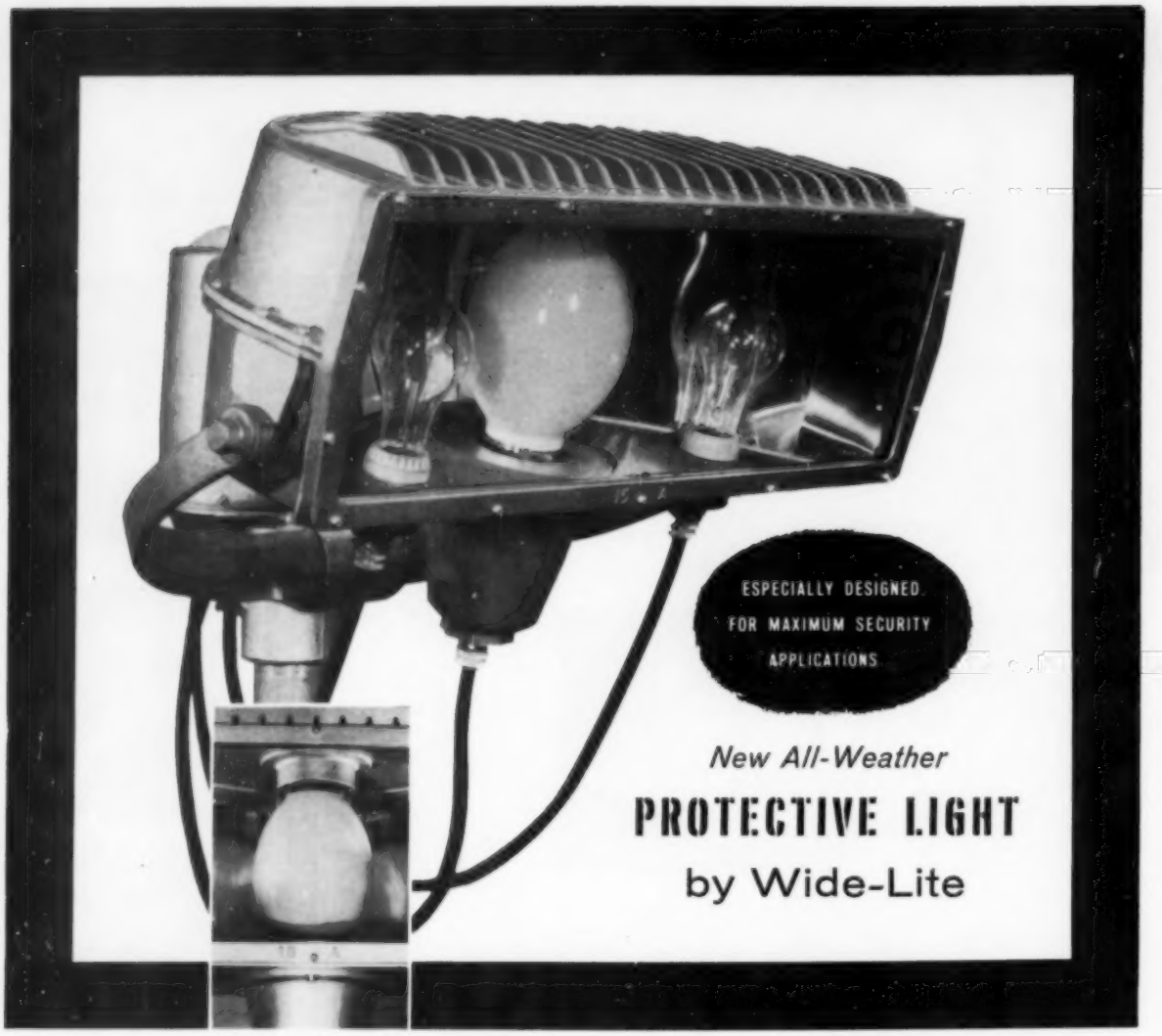






patents pending

SUNBEAM LIGHTING COMPANY LOS ANGELES, CALIFORNIA GARY, INDIANA



Wide-Lite's exclusive "Stabilux Socket" holds the large mercury vapor lamp securely in place . . . virtually eliminates lamp breakage and rupture due to physical shock. (Patent pending.)

The only floodlight that combines the efficiency of color-corrected mercury vapor lamps with the instantaneous light of incandescent lamps.

GREATER COVERAGE . . . Wide-Lite's pattern is broad and unusually uniform . . . makes possible large area coverage without distracting glare or dark shadows.

GREATER PROTECTION . . . any one of Wide-Lite's three lamps will continue to burn *even if the other two are rendered inoperative.*

LOWER OPERATING LIMITS . . . Only Wide-Lites make possible use of efficient mercury vapor lamps *in temperatures as low as -65° F.*

STRONGER CONSTRUCTION . . . only Wide-Lites offer a rugged *cast* aluminum protective body independent of reflector, shock-resistant tempered glass lens, and a vibration-resistant, grip-type lamp receptacle.

Write today for complete information on the new all-weather protective light by Wide-Lite!

WIDE-LITE.

Manufactured by

WIDE-LITE CORPORATION P. O. Box 191 Houston 1, Texas

In Canada: Wide-Lite Division of Wakefield Lighting, Limited, London, Canada

OUTDOOR AREA LIGHTS • INDOOR LUMINAIRES • MOBILE WORKING LIGHTS • SPORTS LIGHTS • PROTECTIVE LIGHTS

(*Continued from page* 16A)

designed and built Disneyland. Luncheon was at the Mount Vernon Country Club and a cocktail hour on return from the tour preceded the dinner-dance.

Conference Chairman James R. McCullogh, of Boulder, Colo., was assisted by Chairmen of the Sections and Chapters in the Region, who served as Chairmen for the individual sessions.

CONFERENCE PROGRAM

May 11—Morning

Opening Address—A. E. Fleming, General Electric Supply Co., Regional Vice-President, Inter-Mountain Region.
Keynote Address: 100 Years of Lighting in Colorado—Harold Rankin, Public Service Co. of Colorado.

Chairman, William Stultz, Southern Colorado Chapter
IES Progress Report—E. A. Linsday, General Electric Co., Cleveland, Ohio
Quantity and Quality Requirements of Lighting—J. J. Neidhart, The Miller Co., Meriden, Conn.
Luncheon
The Professional Engineer—John Kraehenbuehl, Colorado College, Colorado Springs, Colo.

May 11—Afternoon

Chairman, Bob Godemann, Arizona Section
Electroluminescence—Harold Brandt, Westinghouse Electric Corp., Denver, Colo.
Self-Ballasting Mercury Lamps—Herbert A. Anderson, Duro-Test Corp., North Bergen, N. J.

Chairman, J. Homer Shaw, Utah Chapter
Seeing Color Under High-Intensity Illumination—Robert R. Wylie, Sylvania Electric Products, Salem, Mass.
Ballasts of the Future—Eugene C. Pauly, General Electric Co., Danville, Ill.

May 12—Morning

Chairman, A. W. Boehning, Jr., New Mexico Chapter
Modern Lighting Maintenance—James Watson, Fluorescent Maintenance Co., Denver, Colo.
My Most Interesting Lighting Job Contest
Large Parking Area Lighting—Wallace Weld, Revere Electric Manufacturing Co., Chicago, Ill.
Control of Light with Plastic—Gene Rae, The Holophane Co., New York, N. Y.
Martin Plant Tour.

Appreciation Expressed For Puget Sound Seminar

Proof that work in disseminating "the art and science of illuminating engineering" is effectively reaching the right people is always gratifying. Such satisfaction can be felt by the Puget Sound Section of IES, whose recent seminar on Street and Highway Lighting brought praise and appreciation from the State Highway Commission of the State of Washington. In a letter thanking the Section for allowing their personnel to participate in the seminar, the Commission's Department of Highways said: "Meetings of this sort, while held very infrequently, are very valuable in allowing persons interested in street and highway lighting the opportunity to meet, exchange ideas, discuss mutual problems and obtain new ideas in this highly specialized field. We should like to suggest that, if possible, similar meetings be held on an annual basis."

IES Managing Director Dex Hinckley, President George Taylor, present Regional V-P Gene Fleming, incoming Regional V-P (1959-1960) L. S. Reed, and portable lamp which does not meet IES recommendations for hotel lighting.

Milwaukee Scores Again With Tenth Annual Conference

Repeating the success of the previous nine spring lighting conferences, the Milwaukee held its tenth annual meeting on May 8. Theme of the conference was "Street and Highway Lighting" and the attendance of 93 included 11 from out of the state—Indiana, Illinois, Minnesota and Michigan. Program and speakers were:

Welcoming Address—I. L. Illing, Wisconsin Electric Power Co.
Incandescent Sources—William B. Kennedy, Sylvania Electric Products Inc.
Fluorescent Sources—William L. Lowell, General Electric Co.
Mercury Sources—Ralph R. Cheney, Westinghouse Electric Corp.
Fundamental Elements Affecting Street Lighting Design—Warren H. Edman, Holophane Co.
Parking Lot Lighting—E. H. Schaefer, Wisconsin Electric Power Co.
Luncheon
Commercial Street Lighting—Jack Pointer, Wisconsin Power and Light Co.
Residential Street Lighting—G. G. Wheeler, Northern States Power Co.
Highway Lighting—Stacy Standley, Line Material Industries.
State Highway Lighting in Wisconsin—H. O. Price, Wisconsin Highway Commission.

The technical program was followed by a social hour, buffet dinner and attendance at the under-the-lights game between the Milwaukee Braves and the Cincinnati Reds.

Registration fee of $12 included the conference, lunch, social hour, dinner and baseball ticket. The conference was held at the Engineers Society of Milwaukee Building.

Connecticut Industrial Executives Get "Lighting Story"

More than 600 representatives of industrial plant management learned the value of good lighting in industry, through the efforts of a recent series of luncheon meetings in four Connecticut cities. Called "More Light on Connecticut Production," the meetings featured talks by IES President George J. Taylor, E. A. Linsday, Director of Industrial Lighting Applications, General Electric Co., Cleveland, Ohio and Edward Themak, Jr., Supervisor of Market Development, Advertising and Sales Promotion, General Electric Co.

President Taylor emphasized the role of the Society in illumination standards and research, with particular reference to the work of IES Technical Committees and the recent Blackwell researches. Mr. Linsday, in an illustrated presentation on planned lighting systems, brought

(*Continued on page* 20A)

(*Continued from page* 19A)

the point home with case histories of plants where better lighting led to increased production and reduced waste. Sources and lighting systems, new and old, were the subject of Mr. Themak's talk.

The meetings were held on April 14-17 in New Haven, New Britain, Willimantic and Stamford, under the sponsorship of four Connecticut electric utilities —The Connecticut Light and Power Co., The Hartford Electric Light Co., The Housatonic Public Service Co. and The United Illuminating Co.

Aircraft Lighting Committee Holds Two-Day Conference

About 100 people were in attendance at a two-day conference of the Aircraft Lighting Committee, April 15-16, at the Institute of Aeronautical Sciences, Los Angeles, Calif. This was the first meeting as a full committee and the success of this meeting promises well for future activities.

Each of the four sessions had a special theme, with panel discussion by the speakers. The program:

April 14, Morning Session

Welcome by Warren Hulke, Chairman of the Aircraft Lighting Committee.
Light and Seeing—a Science?—C. T. White, United States Navy Electronics Laboratory.
How Much Light?—What is Visual Efficiency?—J. L. Harris, San Diego.
Visual Fatigue—What Is It?—Dr. M. C. Nadell, Los Angeles College of Optometry.
Panel Discussion: The Visual Problems in Aircraft Today—Moderator, Roy Dahlin, Southern California Edison Co.

Fred Foulon and Committee Chairman Warren Hulke at aircraft meeting.

April 14, Afternoon Session

Lighting Problems in the Cockpit—Dean Pierce, Lockheed Aircraft Corp.
Lighting Problems in the Cabin—William J. Strukelj, Convair—San Diego.
Lighting Problems for Servicing and Maintenance—J. A. Aldrich, United Airlines.
Lighting Specifications, Guides and Standards —Walt Fisher, Bureau of Aeronautics.
Techniques for Measuring Light and Lighting —Tom Twist, National Bureau of Standards.
Panel Discussion: Interior Lighting As It Is Done in Today's Aircraft Design and Development—Moderator, George Ledbetter, Illuminator, Inc.

April 15, Morning Session

Visibility—Is It Possible at Today's Speeds?—Michael Fiore, Northrop Aviation.
Conspicuity, a Psychophysical Phenomenon—Dr. Nick Bond, Dunlap & Associates.
Attention, Vigilance and Human Error—Dr. John Lyman, Department of Engineering, UCLA.
Factors in Design of Navigation Systems—Theodore Projector, Lighting Consultant.
Panel Discussion: Exterior Lighting—Is It Obsolete?—Moderator, Wes Woodson, Convair-San Diego.

April 15, Afternoon Session

Miniature Incandescent Lamps—The State of the Art—Al Mortensen, General Electric Co.
Fluorescent Lamps—The State of the Art—Philip Massie, Day-Ray Products, Inc.
Exterior Lamps and Fixtures—The State of the Art—Miles Tyler, Douglas Aircraft.
Power Requirements and Systems—The State of the Art—Charles Milliken, Lockheed Aircraft.
Lighting Mockup—A Lighting Test Stand—Peter Downey, Boeing-Seattle.
Panel Discussion: Industry's Role in Improving Aircraft Lighting—Moderator, Jim Ransford, Douglas Aircraft.

Warren Hulke, Soderberg Manufacturing Co., was chairman of the meeting; Wes Woodson, Convair-San Diego was secretary, and Kenneth Dean of General Electric Co. was local arrangements chairman. The cooperation of the aircraft companies — Douglas Lockheed, North American, Northrop and Convair—was greatly appreciated.

PANEL at aircraft meeting: l. to r., Theodore Projector, Paul Greenlee, Michael Fiore, Dr. John Lyman and Dr. Nicholas Bond, Jr.

Back Issues of IE Available

A file of unbound copies of ILLUMINATING ENGINEERING dating from 1938, which belonged to the late George Stickney, is available to any IES member who requests them. Only charge is the payment of shipping expenses. Inquiries should be addressed to Mr. George Stickney, Jr., 126 Market St., Paterson 1, N. J.

Illumination I and II— Toronto University Courses

In cooperation with the Extension Department of the University of Toronto, the Toronto Section of IES has presented two courses in illumination—one basic and the other more advanced. Illumination I was regarded as a prerequisite for the second section. Topics covered and lecturers were:

Illumination I

January 6—Nature and Production of Light—Miss M. G. Currie
January 13—Vision—the Eye—Dr. J. G. Ogilvie
January 20—Vision—the Task—Dr. J. G. Ogilvie
January 27—Lighting Terms and Laws of Illumination—G. E. Davidson
February 3—Measurements—G. E. Davidson
February 10 and 17—Flux, Illumination and Brightness Calculation—Prof. V. L. Henderson
February 24—Control of Light—A. Birkhoff
March 3—Illumination for Seeing—Quantity and Quality—H. F. Davidson
March 10 — Source Characteristics — H. C. Jones

(*Continued on page* 22A)

The right Light Transmission...Color...Shape...and Toughness...
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But when that "Gob" has been properly pressed, hardened, annealed and inspected—the finished lens is the product of a complete engineering service.

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Swissvale, Pennsylvania

SOME of the people responsible for the Toronto Lighting Courses, l. to r.: front row, Miss M. G. Currie, G. E. Davidson; back row, N. W. Bethune, B. Quan, H. C. Jones, A. Birkhoff, Prof. V. L. Henderson, Prof. I. Balinkin.

(Continued from page 20A)

Illumination II

January 7—Basic Lighting Design—Miss M. G. Currie
January 14—Lighting Design Problems—Miss M. G. Currie
January 21—Wiring—J. Chisvin
January 28—Wiring Problems—J. Chisvin
February 4—Lighting Economics—Bruce Quan
February 11—Architectural Coordination—I. Grossman
February 18 — Daylight Design Principles — H. F. Davidson
February 25 — Brightness and Glare — G. E. Davidson
March 4—Problems Involving Vision at Low Levels of Illumination—Miss M. G. Currie
March 11—Light, Color and Human Beings—Prof. I. Balinkin

Similar courses are scheduled for next year, the first to start in October and the second early in January. The Section's Education Committee is composed of N. W. Bethune, Chairman, and Bruce Quan, Derwent Lewis and Miss M. G. Currie. Miss Currie served as Course Director.

Meetings were held on Tuesdays and Wednesdays at the Engineering Building of the university. Tuition for each course was $15.

From the Desk of the President

In the February issue of IE I spoke about the importance and variety of our 25 main technical committees and the dozens of subcommittees, all striving by group effort to determine, clarify or assemble information that will be valuable to other IES members. For the individual member, or for two or three working as a team, there are several avenues open for disseminating information. These include talks at Section and Chapter meetings, at the trade symposiums, by article in ILLUMINATING ENGINEERING and other publications, and by papers presented at our annual National Technical Conferences.

It is the latter of these avenues to which my comments will refer this month. To many members, the National Technical Conference is the most glamorous event on the Society's calendar. To an even larger group, perhaps, the NTC is an unknown quantity because those members have never had a convenient opportunity to attend one.

The principal purpose of our National Technical Conference is to present new engineering and scientific material which will significantly further the art of illumination. Discussion following the platform presentations of such new information gives other members the opportunity to voice affirmative, correlating or contrary experience and opinion, with final rebuttal by the author. This democratic process, stemming from the old Town Meetings of colonial days, assures our Society that proposals of individuals are scrutinized by their peers.

The over-all responsibility for the conference rests with the National Technical Conference Committee. Local arrangements are made by a Conference Executive Committee, whose members head up various important conference functions; hotel accommodations, meeting rooms, registration, publicity, entertainment, etc. The selection of subjects to be presented at the Technical sessions is made by the Papers Committee, by appraising the various proposals submitted by members, and in some cases by requesting certain authorities to contribute a particularly timely subject.

The Society has for many years held the National Technical Conference in different parts of the country from year to year. Following a pattern approved by Council several years ago, about half the locations are within one of our four Regions having the highest percentage of IES members. Usually, every other year will be at such a "central" location in the Northeastern, East Central, Great Lakes or Midwestern Regions.

This year the conference will be in San Francisco, using the Fairmont and Mark Hopkins as headquarters hotels. The technical sessions begin on Monday, September 7th (Labor Day) and the conference ends with the President's Reception and Banquet on Thursday night, September 10th. The Conference Executive Committee is headed by John Walsh, and many plans have been made to insure that all members and guests attending will have a worthwhile and pleasant visit.

Various articles and announcements will be reaching you in the next few months, and January IE gave the highlights of the planned ladies program. These included sight-seeing trips (along with a boat ride) a tour to the ancient wineries in Napa and Sonoma counties, an oriental luncheon and fashion show in Chinatown, etc. The men will get an opportunity to relax with their ladies Tuesday afternoon and evening, winding up with a real Western-style barbecue and fun at the Orinda Country Club.

Already the Papers Committee has selected an outstanding group of papers on applications (more than ever in this category), lighting calculations, light sources, photometry, research, daylighting, street lighting and miscellaneous subjects. And the Progress Report is always an outstanding event. There's bound to be helpful information for every member, and an opportunity to swap experience and lighting solutions. Many will be making it a vacation trip too—some going on to Hawaii after the conference!

So circle the dates on your calendar now (September 7 through 10 — but get there in time for the deep-sea fishing September 6th) and start making plans now!

GEORGE J. TAYLOR
President, 1958-1959

(News continued on page 25A)

New!

HIGH-LEVEL ECONOMY LIGHTING WITH
WHEELER-FULLERTON **400-WATT MERCURY**

METROPOLITAN LUMINAIRES

WITH OR WITHOUT BUILT-IN BALLAST

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An ideal fixture to use where critical seeing tasks call for high quality illumination. Meeting or exceeding all RLM requirements for 20%-30% upward component fixtures, the Diamond I Series offers exceptional efficiency with outstanding installation and maintenance features.

The Diamond I Series is now available for use with high output and very high output lamps in addition to conventional Rapid Start and Instant Start models. Write for complete information.

On choosing Sylvania's Diamond I fixtures to light this smooth-running plant, Chief Industrial Engineer Henry Bernbaum states, "We set rigid lighting specifications and the Sylvania fixtures met all of them from every angle. We now have the quality lighting system we need and we obtained it at a reasonable cost."

The next time *you* face a lighting problem in a new plant or old, look first to Sylvania. The wide variety of industrial fixture types offered by Sylvania allows you to choose the particular fixture that suits your application best. No matter which type you pick you'll know you're getting quality fixtures at a reasonable price.

For *all* of your industrial and commercial lighting needs . . . Go Modern with Lighting by SYLVANIA.

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IES Officers Elected For 1959-1960

At the meeting of the IES Council on June 18, 1959, the Committee of Tellers presented their report on the results of the recent Society election. The following have been elected to the offices indicated, for the year beginning October 1, 1959.

GENERAL OFFICERS

President—J. B. Browder, Georgia Power Co., Atlanta, Ga.

Vice-President—J. R. Chambers, Appleton Electric Co., Chicago, Ill.

General Secretary—C. W. McCormick, Connecticut Light & Power Co., Hartford, Conn.

Treasurer—G. Franklin Dean, Toronto Hydro-Electric System, Toronto, Ont.

Directors (Until 1962)—J. S. Hamel, 1122 Rossmoyne St., Glendale, Calif.; W. P. Lowell, Jr., Sylvania Electric Products, Inc., Salem, Mass.

Regional Vice-President—Canadian Region—to be appointed; *East Central Region*—C. D. Miller, Duquesne Light Co., Pittsburgh, Pa.; *Inter-Mountain Region*—L. S. Reed, L. S. Reed Co., Denver, Colo.; *Southeastern Region*—C. L. Cannon, 155 Nassau St., N.W., Atlanta, Ga.; *Southwestern Region*—J. B. Deck, Jr., Texas Power & Light Co., Cleburne, Texas.

ALABAMA SECTION

Chairman—M. R. Hazzard, Hazzard, McRay and Cone, 3015 6th Ave. So., Birmingham, Ala.

Vice-Chairman—R. P. Fulmer, Westinghouse Electric Corp., 1407 Comer Bldg., Birmingham, Ala.

Secretary—R. D. Steele, Alabama Power Company, 2100 1st Ave. No., Birmingham, Ala.

Board of Managers—W. J. Broughton, Jr., Samuel Davidson, W. D. Parker, D. W. Traylor, Jr.

ALAMO SECTION

Chairman—K. L. Cotton, General Electric Co., San Antonio, Texas.

Vice-Chairman—T. F. Beach, Southern Equipment Co., San Antonio, Texas.

Secretary—L. W. Travis, Beretta, Greenslade & Associates, Inc., San Antonio, Texas.

Board of Managers—Gerard Baker, W. G. Darley, W. S. Smith, M. E. Staley, R. V. Barnes (tie with Gerard Baker).

ARIZONA SECTION

Chairman—R. W. Godemann, Arizona Public Service Co., Phoenix, Ariz.

Vice-Chairman—S. S. Lambe, Salt River Project, Phoenix, Ariz.

Secretary—William Benndorf, William Benndorf Co., Phoenix, Ariz.

Board of Managers—W. B. Keller, Glenn Kiger, L. L. Pike, W. L. Sage.

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Chairman—H. G. Foster, Northern Electric Co., Ltd., Vancouver, B. C.

Vice-Chairman—J. E. Baker, Vancouver Lighting Co., Vancouver, B. C.

Secretary—W. J. Butler, B. C. Electric Co., Ltd., Vancouver, B. C.

Board of Managers—A. M Anderson, C. R. Coldwell, A. J. McIntosh, A. E. W. Stedman.

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Vice-Chairman—K. W. Cobb, 2430 Pennsylvania Ave., N.W., Washington, D. C.

Secretary—C. E. O'Daniel, Potomac Electric Power Co., Washington, D. C.

Board of Managers—J. E. Butler, R. M. Lowry, A. J. Rugo, R. C. Marshall.

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Vice-Chairman—R. C. Swanson, Jr., Niagara Mohawk Power Corp., Syracuse, N. Y.

Secretary—D. R. Brown, Crouse-Hinds Co., Syracuse, N. Y.

Board of Managers—J. C. Bannigan, P. J. Carpenter, W. F. Crosby, Jr., J. S. Haney.

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Vice-Chairman—J. J. Neidhart, The Miller Co., Meriden, Conn.

Secretary—R. H. Chase, Hartford Electric Light Co., Hartford, Conn.

Board of Managers—D. S. Gaidosz, C. C. Harper, L. A. Senofonte, H. R. Young.

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Vice-Chairman—W. M. Scholes, Omaha Public Power Dist., Omaha, Nebr.

Secretary—R. W. Brewer, Iowa Public Service Co., Sioux City, Iowa.

Board of Managers—C. G. Christensen, W. J. Cook, E. C. Knudson, F. D. Mallette.

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Vice-Chairman—John C. Gould, Niagara Mohawk Power Corp., Troy, N. Y.

Secretary—C. E. Waldron, Niagara Mohawk Power Corp., Albany, N. Y.

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Vice-Chairman—B. P. Best, 1450 Coral Way, South, St. Petersburg, Fla.

Secretary—Seymour Bell, Sarasota Electric Corp., Sarasota, Fla.

Board of Managers—J. K. Boyle, C. V. Brown, Sam Carastro, R. Y. Fernandez.

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Board of Managers—Guy De Leuze, J. C. Epperson, C. W. Macy, Harold Skootsky.

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Board of Managers—G. G. Harper, J. L. Krall, Jay Mears, Harvey Owings, Jr., Norman Pattee.

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Secretary—M. B. Wolfe, Public Service Co. of Indiana, Inc., Terre Haute, Ind.

Board of Managers—R. H. Merrill, N. J. Reinhart, C. O. Rice, N. F. Schnitker.

(Continued on page 26A)

THIRD meeting of the Buckeye Lighting Study Group, May 20 in Columbus, Ohio, featured guest speaker Richard Slauer, IES Vice-President. Shown with him are: l. to r., Judson Lord, Michael Leahy, Byron Russell, Mr. Slauer and Harold Risler. The group was chartered by Council as an IES chapter June 18.

(Continued from page 25A)

IOWA SECTION

Chairman—Mrs. Mary E. Stafford, Thomas Electric Co., Des Moines, Ia.
Vice-Chairman — R. F. Gruhl, Davenport Electric Contract Co., Davenport, Ia.
Secretary—L. J. Kingsley, Crescent Electric Supply Co., Des Moines, Iowa.
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Vice-Chairman—Richard Dunlop, Dunlop Lighting, Baltimore, Md.
Secretary—Simon E. Ehrlich, Excello Public Service Corp., Baltimore, Md.
Board of Managers—R. C. Desor, M. E. Gillespie, P. J. Puckett, H. M. White.

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Vice-Chairman — Paul E. Wehner, 8528 Byers Road, Miamisburg, Ohio.
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MILWAUKEE SECTION

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Vice-Chairman — Edwin Schnoll, Schnoll Lighting Sales, Milwaukee, Wis.
Secretary—C. A. Knoerr, Knoerr & Fischer, Inc., Milwaukee, Wis.
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Secretary — Paul M. Crosby, Cambridge Electric Light Co., Cambridge, Mass.
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Vice-Chairman—G. C. Schroeder, Jr., Schroeder & Associates, New Orleans, La.
Secretary — James A. Stelly, Gulf States Utilities Co., Baton Rouge, La.
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NORTHWESTERN OHIO SECTION

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Vice-Chairman, Paul Hood, Eggleston & Son, Toledo, Ohio.
Secretary—A. C. Wegener, Toledo Edison Co., Toledo, Ohio.
Board of Managers—D. I. Kirby, H. B. Millar, S. E. Nagel, E. A. Winkeljohn.

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Vice-Chairman—Jack R. Seay, Seay Electric Co., Tulsa, Okla.
Secretary — J. C. Pensfeather, Leon B. Senter, Architect, Tulsa, Okla.
Board of Managers—R. H. Bowyer, C. T. Enochs, W. J. Klaus, H. O. West.

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Vice-Chairman—Fred A. Farley, Benjamin Electric Mfg. Co., Portland, Ore.
Secretary—W. G. Pracejus, General Electric Co., Portland, Ore.
Board of Managers—R. M. Boynton, J. T. Cottingham, A. B. Evans.

OTTAWA SECTION

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Vice-Chairman—M. J. Cote, 1800 Bank St., Ottawa, Ont.
Secretary—W. H. Johnson, Holophane Co., Inc., Toronto, Ont.
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PALMETTO SECTION

Chairman — R. L. Adams, South Carolina Electric & Gas Co., Columbia, S. C.
Vice-Chairman—R. E. Faucett, General Electric Co., Hendersonville, N. C.
Secretary—Mireille W. Thompson, General Electric Co., Hendersonville, N. C.
Board of Managers—R. N. Campbell, A. M. Bjontegard, E. B. Rogers, Jr., B. G. Watson.

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Vice-Chairman—E. H. Henrie, The Howard P. Foley Co., Philadelphia, Pa.
Secretary—Stanley W. Purdum, Philadelphia Electric Co., Philadelphia, Pa.
Board of Managers—V. W. Kafka, D. D. Lees, G. L. Reynolds, K. L. Williams.

PITTSBURGH SECTION

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Vice-Chairman — D. C. Thomas, Sylvania Electric Products, Inc., Pittsburgh, Pa.
Secretary—J. B. McNall, West Penn Power Co., Greensburg, Pa.
Board of Managers—J. P. Boyden, Jr., J. S. Frizzell, J. A. Hodges, H. J. Mazur.

PUGET SOUND SECTION

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Vice-Chairman—G. D. Wirt, Puget Sound Power & Light Co., Bremerton, Wash.
Secretary—J. A. Fredrickson, General Electric Co., Seattle, Wash.
Board of Managers — G. F. Fitzmaurice, R. E. Jones, E. A. Matlock, C. R. Nelson.

(Continued on page 28A)

problem

An easily maintained, integrated fixture was needed for Welton Becket's dramatic "squares of light" ceiling in the lobbies and offices of Southland Life's spectacular 42-story Southland Center in Dallas.

solution

ACHILLES by Lighting Dynamics was specified for the lobby... and it's companion Apollo was used in the offices throughout the center. Achilles is a highly versatile fixture series ideal for this demountable acoustical ceiling—just as it is for countless other ceiling suspension systems. It's quickly installed with a drop-in installation and has easy maintenance with press-to-open catches and hook-on hinges. Durable, Bonderized and electro-static, high-reflectance finishes... FOR MORE COMPLETE INFORMATION, call your Lighting Dynamics representative, or write to Lighting Dynamics, 802 West Whittier Blvd., Whittier, California or Lighting Dynamics, 8700 Ambassador Row, Dallas, Texas.

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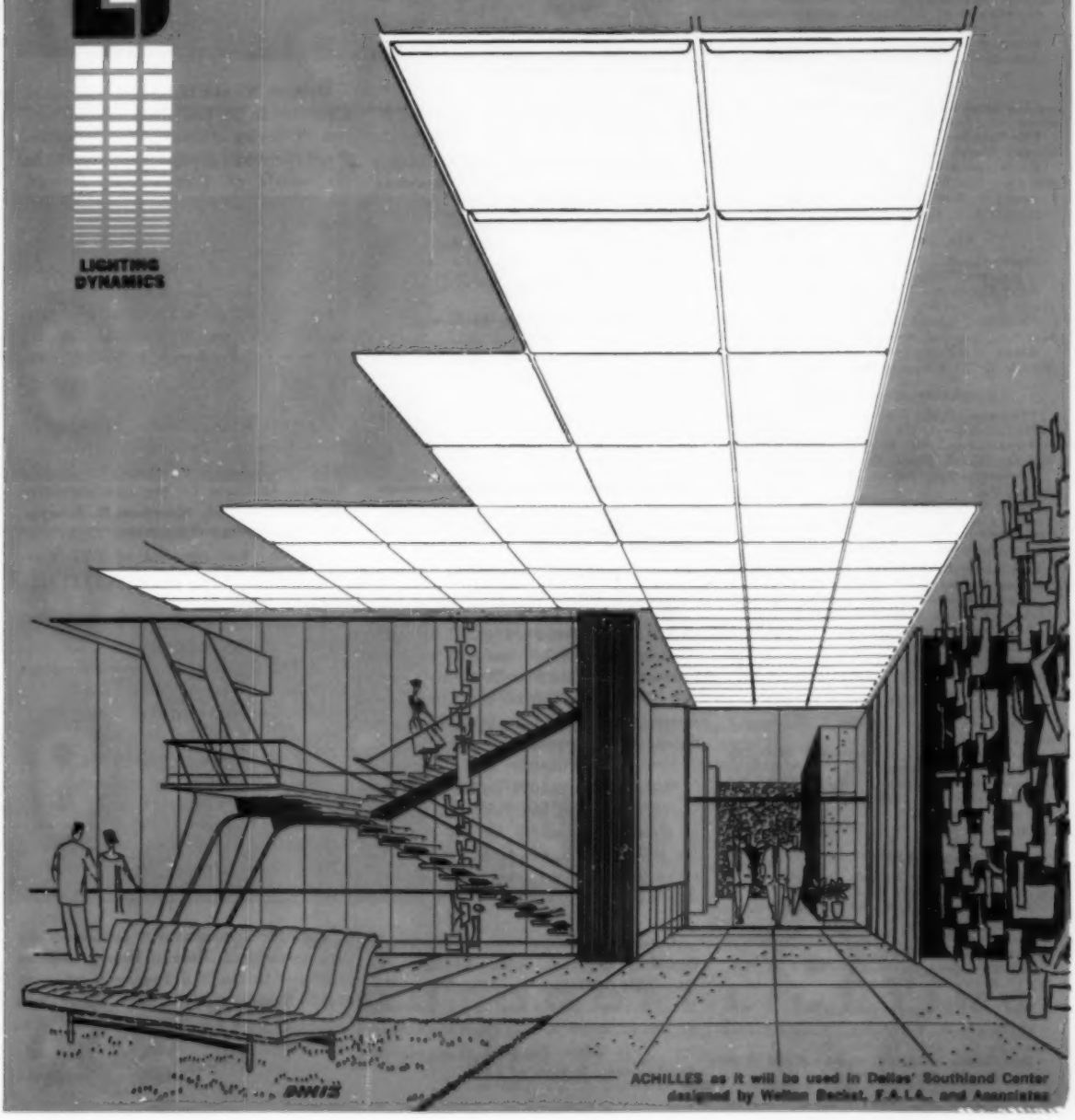

ACHILLES as it will be used in Dallas' Southland Center designed by Welton Becket, F.A.I.A., and Associates

(Continued from page 26A)

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Vice-Chairman—J. E. Watson, Fluorescent Maintenance Co., Denver, Colo.
Secretary—Fred H. Rosenquist, Public Service Co. of Colorado, Denver, Colo.
Board of Managers—H. E. Gypson, E. D. Heintze, L. S. Reed, R. S. Schrenk.

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Vice-Chairman—Paul Q. Olschner, Westinghouse Electric Corp., St. Louis, Mo.
Secretary — N. L. Krause, Sach's Electric Co., St. Louis, Mo.
Board of Managers—R. D. Cohen, E. W. Stohlmann, Jr., R. J. Welch, C. H. Zurheide.

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Vice-Chairman—Robert O. Gray, California Electric Works, San Diego, Calif.
Secretary—Alan J. McCutcheon, Jr., 861 6th Ave., San Diego, Calif.
Board of Managers — W. J. Beran, F. E. Claycomb, J. P. Conner, E. C. Rice.

SAN JACINTO SECTION

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Vice-Chairman — D. L. Copeland, Crouse Hinds Co., Houston Texas.
Secretary—Robert Putterman, R. A. Putterman Co., Houston, Texas.
Board of Managers—G. L. McGonigle, J. E. Musick, G. H. Simpson, Bill Sneed.

SOUTHEAST FLORIDA SECTION

Chairman—F. E. Yanaros, Florida Power & Light Co., Hialeah, Fla.
Vice-Chairman—G. H. Gill, Century Lighting, Inc., North Miami, Fla.
Secretary—Bess Jones, 95 N. E. 71st St., Miami, Fla.
Board of Managers—F. H. Emmett, Paul Foster, J. M. Hefley, D. A. Powel.

SOUTHERN CALIFORNIA SECTION

Chairman—B. J. Hartmann Flood-Lite Service, Los Angeles, Calif.
Vice-Chairman—Edward Balogh, Sunbeam Lighting Co., Los Angeles, Calif.
Secretary — J. Roy Jones, Westinghouse Electric Corp., Los Angeles, Calif.
Board of Managers—B. F. Jones, F. B. Lee, J. N. Robertson, L. N. Tilson.

TAR HEEL SECTION

Chairman—T. Llew Cordle, J. N. Pease & Co., Charlotte, N. C.
Vice-Chairman—E. C. Gatewood, 4400 Collingwood Drive, Charlotte, N. C.
Secretary — Everett D. Stevens, Carolina Power & Light Co., Raleigh, N. C.
Board of Managers—E. K. Kraybill, A. M. Neely, D. E. Rouse, N. L. Simmons.

TENNESSEE VALLEY SECTION

Chairman—J. R. Harrell, Tafel Electric & Supply Co., Nashville, Tenn.
Vice-Chairman—D. R. Bills, General Electric Co., Memphis, Tenn.
Secretary—W. E. Jones, Nashville Electric Service, Nashville, Tenn.
Board of Managers—Joe Fowler, J. B. Holt, W. H. Ridley, W. B. Roberts.

TORONTO SECTION

Chairman—R. P. Lindsay, Canadian Line Materials Co., Ltd., Toronto, Ont.
Vice-Chairman—A. W. Henschell, 51 Wellington St., W., Toronto, Ont.
Secretary—A. J. Brown, Mitchell Mfg. Co., Toronto, Ont.
Board of Managers—N. W. Bethune, L. Collins, K. R. Ormrod, J. W. Townsend.

TWIN CITY SECTION

Chairman — John C. Newhouse, Northern States Power Co., Minneapolis, Minn.
Vice-Chairman—John Bahnak, 711 W. Lake St., Minneapolis, Minn.
Secretary—Charles Duepner, B. M. D. & R., Inc., Minneapolis, Minn.
Board of Managers—Conrad J. Aas, G. P. Ellison, H. J. Hanson, F. T. Tillemans.

UTAH SECTION

Chairman—J. H. Shaw, Utah Power & Light Co., Salt Lake City, Utah.
Vice-Chairman—W. A. Huckins, Jr., 1320 Laird Avenue, Salt Lake City, Utah.
Secretary—H. S. Sherwood, Utah Power & Light Co., Salt Lake City, Utah.
Board of Managers—David Merrill, W. L. Shaw, D. C. Thomas, C. J. Vacher.

VIRGINIA SECTION

Chairman—W. G. Cornelius, 2112 Whitewood Road, Richmond, Va.
Vice-Chairman—L. S. Reams, E. I. DuPont de Nemours, Inc., Richmond, Va.
Secretary — R. W. Thomas, Chewning & Welmer, Inc., Richmond, Va.
Board of Managers—P. L. Carr, W. L. McCauley, W. A. Sowers, M. C. Stribling.

WESTERN MICHIGAN SECTION

Chairman — L. L. Nurnberger, Consumers Power Co., Traverse City, Mich.
Vice-Chairman—S. A. Faren, Graybar Electric Co., Inc., Grand Rapids, Mich.
Secretary—J. Q. Miller, Consumers Power Co., Muskegon, Mich.
Board of Managers—J. W. Gentry, E. A. Gonya, Jr., R. C. Graham, A. B. L. Slenker.

WESTERN NEW YORK SECTION

Chairman—T. E. Barhite, Jr., New York State Electric & Gas Co., Lockport, N. Y.
Secretary—W. J. McCarthy, Niagara Mohawk Power Corp., Buffalo, N. Y.
Board of Managers—J. M. Berry, W. E. Hayes, R. R. Herget, B. F. Lyth, Jr., G. D. Rowe.

ABOUT PEOPLE

Dr. Herbert Trotter, Jr., has been elected Senior Vice-President of Sylvania Electric Products Inc. and will have his headquarters at the New York City executive offices. Dr. Trotter, a physicist, assumes his new duties immediately in charge of engineering and research.

Westinghouse Electric Corp., Lamp Division, has named **Dr. John W. McNall** as director of research for the division. Dr. McNall replaces **E. G. F. Arnott,** who asked to be released from administrative duties because of health.

Cecil L. Cannon has been named Southern Regional Sales Manager for Day-Brite Lighting, Inc., St. Louis, Mo. Mr. Cannon's offices are at 34 Eleventh St., N. E., Atlanta, Ga. He is the incoming (1959-1960) Regional V-P of the Southeastern Region of IES.

Annual Meeting

In accordance with Article VIII Section 1 of the Constitution of the Illuminating Engineering Society, the Annual Meeting will be held in conjunction with the National Technical Conference in San Francisco. The Meeting will be held at 10:10 a.m. at the Opening Session of the Conference, Monday, September 7, 1959, at which time the National Officers will report to the membership.

Delbert W. Shirley, Jr., has accepted a position in the Electronic Sciences Section of Boeing Airplane Co., in Seattle, Wash. Professor Shirley was formerly on the faculty of Oregon State College, where he was in charge of the IES Student Branch.

Appointment of **William A. Rotunno** as marketing specialist, Panelescent lamps, for Sylvania Lighting Products, Salem, Mass., has been announced. He will report to **Frederick A. Wolfe,** product sales manager.

Allen S. King, president of Northern States Power Co., Minneapolis, Minn., has been installed as President of the Edison Electric Institute for the administrative year of 1959-1960. **Sherman R. Knapp,** President of the Connecticut Light and Power Co., was installed as EEI Vice-President.

George W. Ross has been named Milwaukee district sales manager for Sylvania Lighting Products, succeeding **John F. Dill.** Mr. Ross was formerly assistant district sales manager in Chicago.

Ray E. Adams has joined the firm of Donald S. Gleason & Associates who represent Prescolite Manufacturing Co., John C. Virden Co., and Lighting Dynamics. Mr. Adams was formerly Lighting and Heating Manager for North Coast Electric Co., in Seattle.

Lighting Dynamics also announces the appointment of **Merwin Hooey** as sales engineer in the San Francisco office, at 1485 Bayshore Blvd. Mr. Hooey was formerly with All-Brite Fluorescent Fixtures, Inc.

(Continued on page 36A)

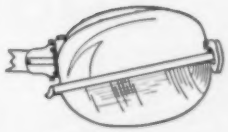
Revere Outdoor Lighting Report

Revere ELECTRIC MFG. CO.

Lighting a city street

The Problem: To illuminate a wide city street uniformly across the total width with high-level light, thus providing fast-moving traffic with utmost visibility for safety.

The Solution: Revere Endoval Luminaires with 400-watt mercury lamps were mounted at 10° tilt on both sides of the wide street, staggered. Distribution pattern selected was I.E.S. Type III which provided uniform light across the entire width of the street, giving the high visibility desired for safe, smooth traffic flow. There is adequate spill light to illuminate sidewalks and parked cars. Endovals mount horizontally if desired.

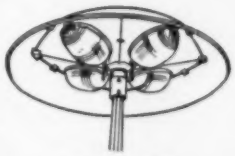


No. 2200 Series
Endoval Luminaire

Lighting a shopping center parking lot

The Problem: To provide high night-visibility for a large shopping center parking lot for ease and safety in driving, parking, and locating parked cars, and to make the shopping center more inviting.

The Solution: High-level, uniform lighting was achieved with 187 Revere 72-inch diameter Ultra-Lites, mounted 34 feet above grade. They use four E-H1 400-watt mercury lamps each, positioned for widest coverage and highest illumination level. Ultra-Lites throw square light patterns which overlap to eliminate "dark spots" and to build up light values in fringe areas.

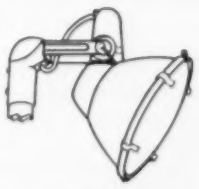


No. 5442 Ultra-Lite

Lighting a flight line

The Problem: To illuminate the wide expanse of a flight line so that routine aircraft operations could be carried on at night with complete convenience and safety.

The Solution: To light the broad flight line intensely and uniformly, 1800 Revere Alzak Aluminum Enclosed Floodlights were used. They were mounted on thirty 80-foot poles, each pole having two banks of 30 floodlights. Each bank has 12 wide-beam floodlights (No. 4211-P) and 18 narrow-beam floodlights (No. 4216-P), with 1500-watt P.S. 52 clear, general-service lamps.



No. 4200
Series Floodlight

Write for Revere's complete catalog of outdoor lighting equipment.

Revere ELECTRIC MFG. CO.

OUTDOOR LIGHTING

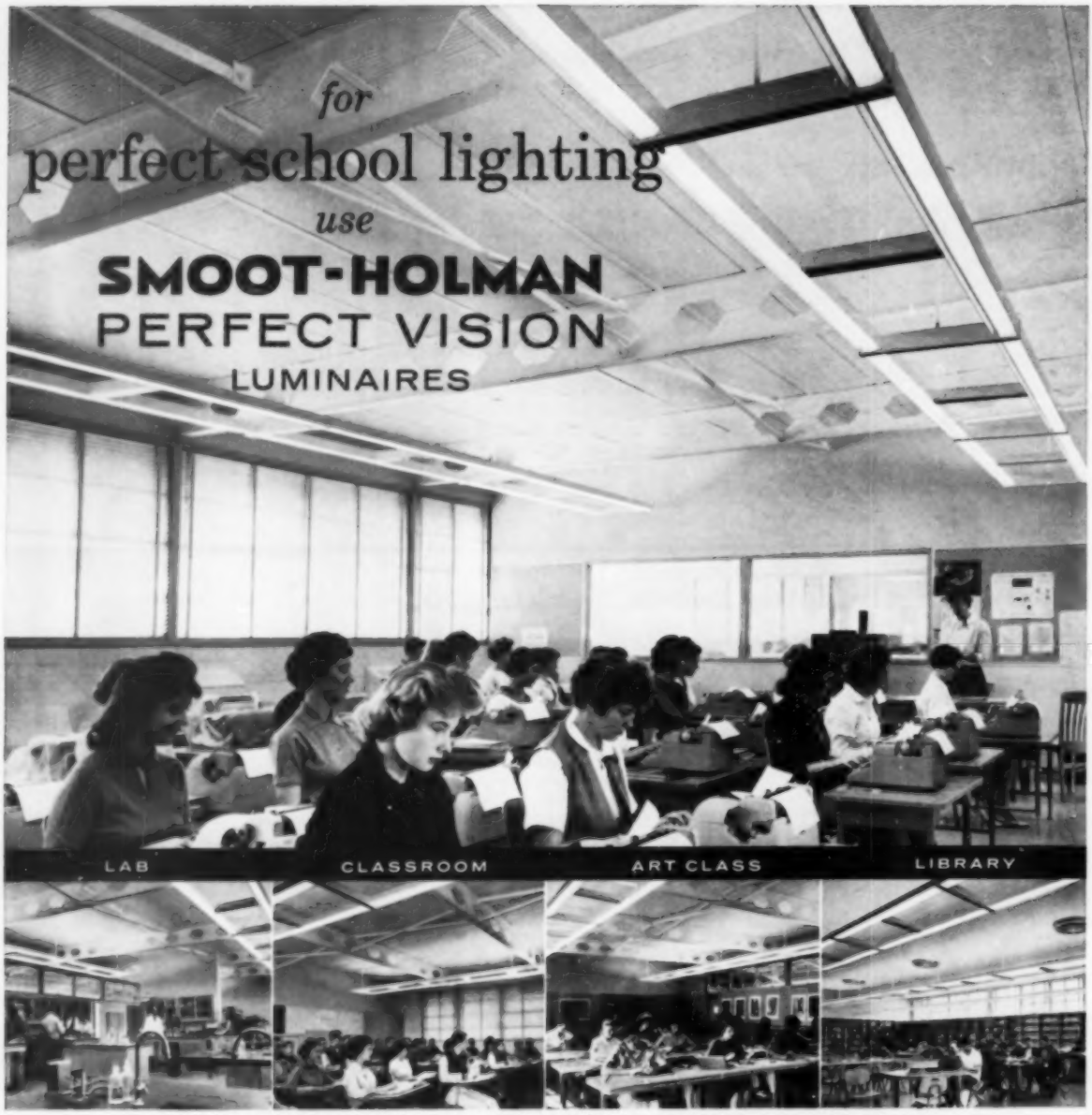
Revere Electric Mfg. Co. • 7420 Lehigh Avenue • Chicago 48, Illinois (In suburban Niles)
Long Distance Phone: NIles 7-6060 • Chicago Phone: SPring 4-1200 • Telegrams: WUX Niles
In Canada: Curtis Lighting, Ltd., Leaside, Toronto, Ontario

for

perfect school lighting

use

SMOOT-HOLMAN PERFECT VISION LUMINAIRES



Architects: Marsten & Weston • Consulting Engineers: Ralph E. Phillips, Inc. • Electrical Contractors: McGee Electric Co.

The above photos were taken at Ganesha High School, Pomona, California, and illustrate the excellent lighting furnished by Smoot-Holman fixtures. Winston Nelson, principal of Ganesha High School states, "The fixtures provide ample foot candle illumination spread evenly over each room. We have noticed an absence of flicker and ballast noise, and we are pleased with the easy maintenance of these fixtures." B. J. Triggs, of Ralph E. Phillips, states, "It has long been recognized that indirect lighting is ideal for close work because of its lack of glare reflections and shadows. However, to obtain higher intensities we have used direct lighting. It was not until the advent of Smoot-Holman P-V series that we found it advantageous to use indirect lighting again. In this school we proved that in a typical classroom (28' x 45') using the 800 m. a. lamps in two rows of P-V fixtures we obtained practically the same illumination intensities as by using conventional 48" rapid start lamps in three rows of direct fixtures. Using only two-thirds of the lineal feet of fixtures and only two-thirds of the lighting outlets and light switches, we actually accomplished a considerable savings to the school board and gave them a better installation."

Send for free, informative brochure, "What You Should Know About School Lighting."

Scientifically designed lighting by **SMOOT-HOLMAN CO.**

321 N. Eucalyptus Ave., Inglewood, Calif.

DOW | PLASTICS

Just announced . . . light-stable polystyrene hits new high in resistance to yellowing!

STYRON® 672 and STYRON 673

VERELITE

The introduction of Styron 672 Verelite and Styron 673 Verelite heralds a significant new advance in fluorescent lighting fixture materials. Both are new, light-stabilized formulations developed by Dow for such applications as light grids, diffusers, and folding curtains.

These new polystyrenes have been fully tested and proved. They exceed the specification adopted jointly by the National Electrical Manufacturers Association, Illumination Engineering Society and Society of Plastics Engineers. In light stability tests, for example, they exhibited a yellowing factor of 2.3 after 500 hours, well within the allowable maximum of 15. General purpose polystyrene formulations reach 15 after only 393 hours of exposure. Thus the non-yellowing characteristics of the Verelite formulations make them an excellent material for fluorescent applications.

Both Styron 672 Verelite, the molding formulation, and Styron 673 for extrusion are now available in a wide range of granulations to meet varying requirements. For more information, return the handy coupon below for technical data and prices.

The addition of these two new polystyrenes brings the already extensive line of Styron formulations to a total of 15. Another milestone for industry's fastest growing group of polystyrene formulations.

THE DOW CHEMICAL COMPANY · MIDLAND, MICHIGAN

America's First Family of Thermoplastics

STYRON*

General Purpose
Styron 666
Styron 689 (Easy flow)

Medium Impact
Styron 330 (Easy flow)
Styron 777
Styron 369 (High heat)

High Impact
Styron 475
Styron 440 (Heat resistant)
Styron 440M (Easy flow)
Styron 480 (Extra-high impact)

Heat Resistant
Styron 683
Styron 700

Light-stable
Styron 672 (Verelite)
Styron 673 (Verelite)

TYRIL* • POLYETHYLENE • PVC

SARAN

ETHOCEL* • PELASPAN* • ZERLON*

*Trademark of The Dow Chemical Company

The Dow Chemical Company
Plastics Sales Department 2115KJ7
Midland, Michigan

Please send me technical information and price schedule on Styron 672 Verelite and Styron 673 Verelite.

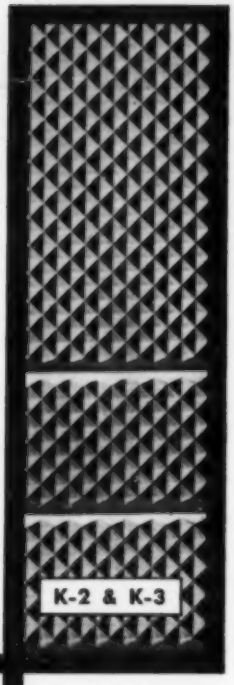
Name_____ Position_____

Firm_____

Address_____

City_____ Zone____ State____

DON'T PAY FOR WASTE ...USE K LITE*



WATCH FOR NEW LENS PANEL K-5

KSH

K LITE PRISMATIC LENS PANELS

*NOW... Prismatic lens panels designed and extruded for 100% usage

K-Lite lens panels are exclusively extruded for standard modular installations in 1 x 2, 1 x 4, 2 x 2 and 2 x 4 units.

GET THE COMPLETE FACTS... SEND FOR BROCHURES NOW

CALL YOUR nearby KSH executive-engineer for on-the-spot service and helpful engineering decisions ... both indoor and outdoor lighting.

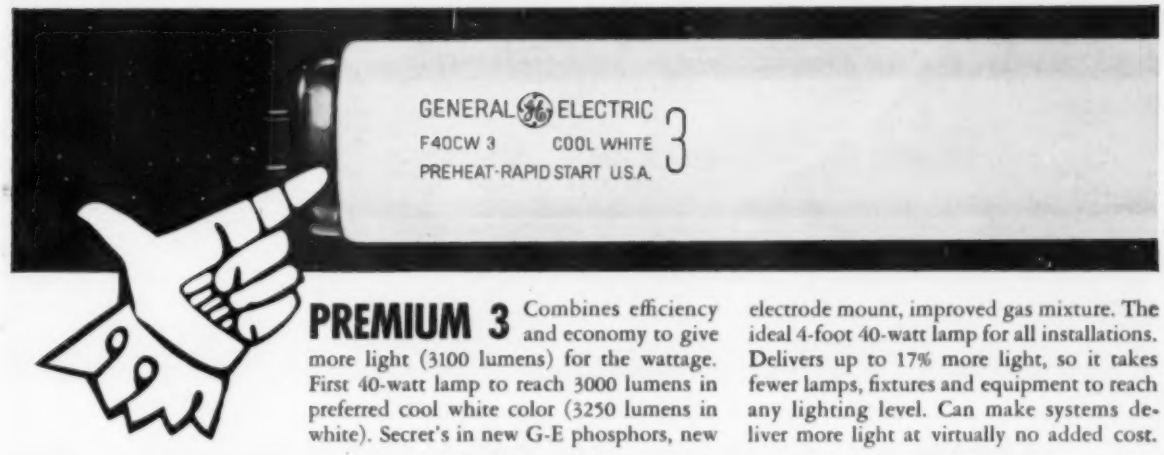
KSH PLASTICS, INC. HIGH RIDGE, MISSOURI

Atlanta • Chicago • Dayton • Detroit • Grand Rapids • Indianapolis • Los Angeles • Milwaukee • St. Louis • Salem

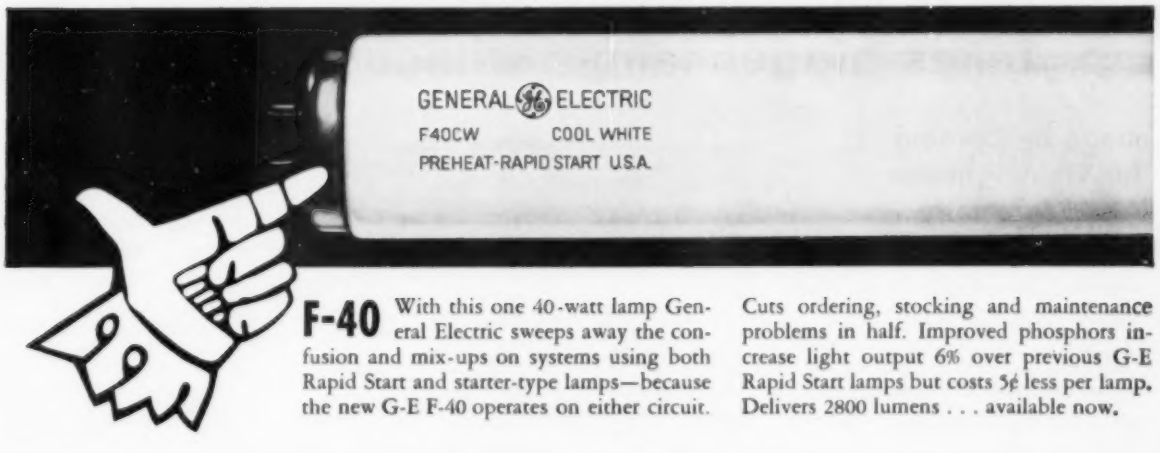
2 (TWO) NEW 40-WATT FLUORESCENTS 2

TWO MORE "FIRSTS" FROM GENERAL ELECTRIC

Know the differences and help each customer pick the best one for his lighting needs



PREMIUM 3 Combines efficiency and economy to give more light (3100 lumens) for the wattage. First 40-watt lamp to reach 3000 lumens in preferred cool white color (3250 lumens in white). Secret's in new G-E phosphors, new electrode mount, improved gas mixture. The ideal 4-foot 40-watt lamp for all installations. Delivers up to 17% more light, so it takes fewer lamps, fixtures and equipment to reach any lighting level. Can make systems deliver more light at virtually no added cost.

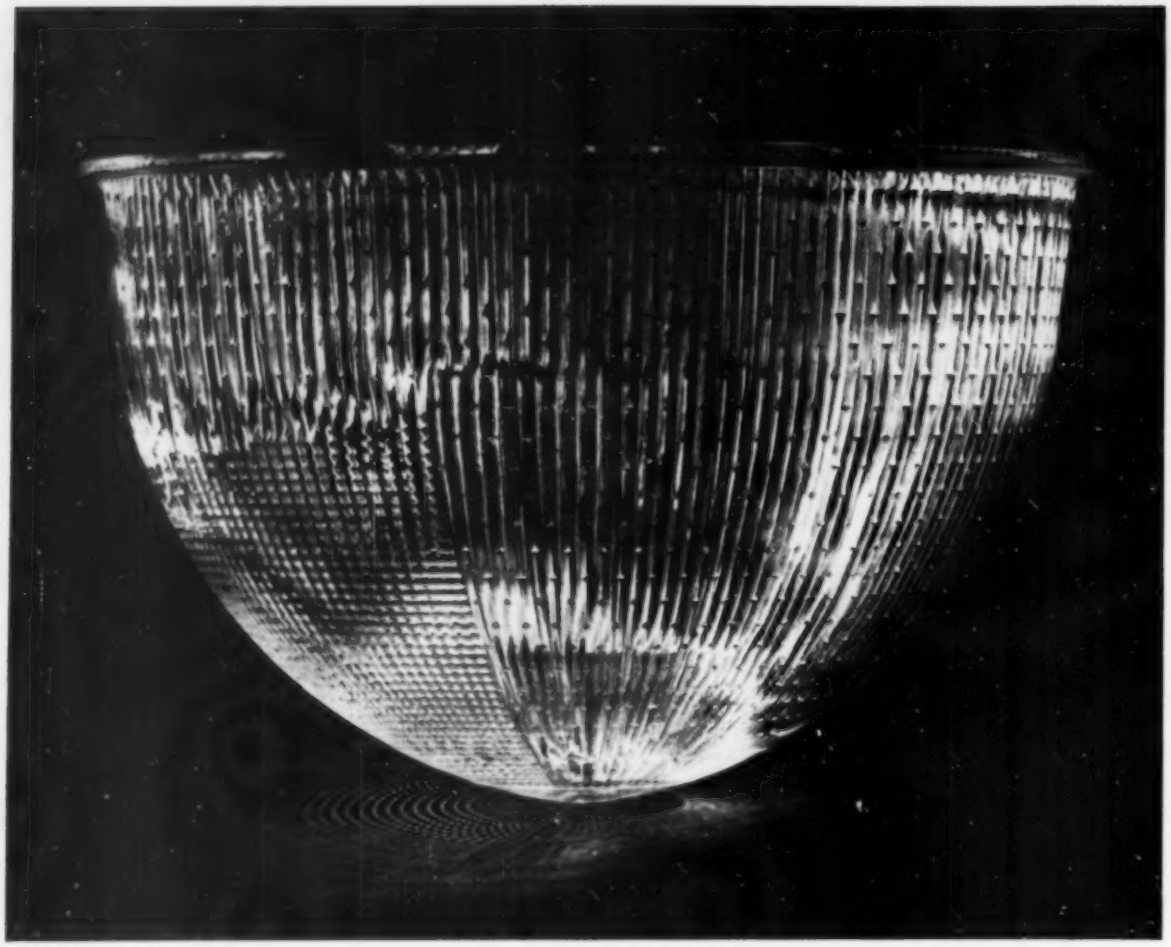


F-40 With this one 40-watt lamp General Electric sweeps away the confusion and mix-ups on systems using both Rapid Start and starter-type lamps—because the new G-E F-40 operates on either circuit. Cuts ordering, stocking and maintenance problems in half. Improved phosphors increase light output 6% over previous G-E Rapid Start lamps but costs 5¢ less per lamp. Delivers 2800 lumens . . . available now.

WANT MORE INFORMATION? Call your General Electric Large Lamp salesman. He'll help you choose the one lamp that's tailor-made to any lighting need. Or write: General Electric Company, Large Lamp Department C-929, Nela Park, Cleveland 12, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC



NEW high-strength PYREX® refractor takes bigger lamps without breaking

made by Corning for Westinghouse AK-10 luminaire

For this particular refractor, Westinghouse chose PYREX brand borosilicate glass No. 7740.

Why?

Because it will stand up under the most severe thermal shock. It will take a bigger lamp without cracking or shattering; ride out the roughest weather, the icy sharpness of winter rain.

And, it's a *tough* refractor, too —can be cleaned without gentleness.

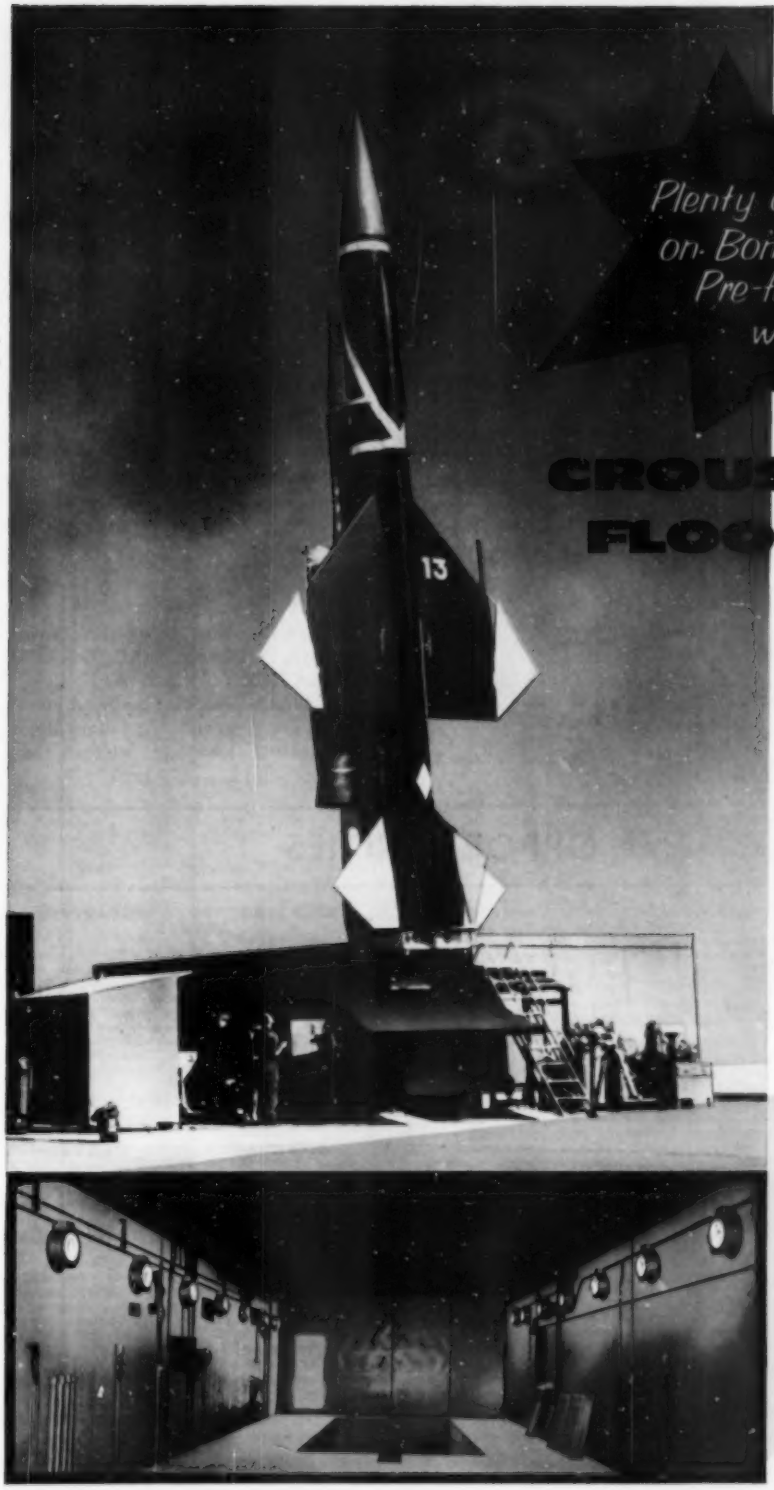
Along with all of these advantages, Corning research and PYREX brand glass No. 7740 make this refractor optically perfect. Its clear prisms are most accurately formed. Its surface is exceptionally durable and abrasion resistant.

It may be that PYREX glassware would answer *your* need for high-wattage lighting. Why not call on Corning experience in glass fabrication and optical research and design?

A brief statement of your problem to Corning Glass Works, 61 Crystal Street, Corning, N. Y., will bring you a prompt answer.

CORNING GLASS WORKS

CORNING MEANS RESEARCH IN GLASS



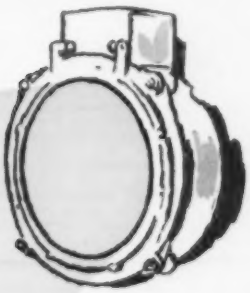
Plenty of Light on Bomarc's Pre-flight with...

CROUSE/HINDS FLOODLIGHTS

Launching shelters at McGuire Air Force Base and other sites are amply lighted by Crouse-Hinds RCD-12 Floodlights. Without eyestrain due to glare or shadow, technicians are able to make the finest adjustments and instrument readings. The entire shelter is literally "flooded" with light.

Floodlights comprise but one of a host of explosion-proof devices supplied by Crouse-Hinds to missile launching and test centers. The complete line includes such items as:

• Motor Starters and Circuit Breakers (and Combinations) • Panel Boards • Instrument Enclosures • Sound-Powered Telephones • Pilot Lights • Mercury Vapor Lighting Fixtures & Floodlights • Junctions • Connectors • Plugs & Receptacles



For complete information on any Crouse-Hinds product—explosion-proof, dust-ignition-proof, weather-resistant or conventional—call your Crouse-Hinds distributor. For application engineering help, contact the nearest Company office below. In the meantime, send for our Bulletin 2707: "Crouse-Hinds in the Missile Industry."

BATTERY OF RCD-12 FLOODLIGHTS eliminates shadow, provides plenty of illumination for close work. The pre-flight scene is really seen!

CROUSE/HINDS
SYRACUSE / NEW YORK

OFFICES: Atlanta Baton Rouge Birmingham Boston Buffalo Charlotte Chicago Cincinnati Cleveland Corpus Christi Dallas Denver Detroit Houston Indianapolis Kansas City Los Angeles Milwaukee New Orleans New York Omaha Philadelphia Pittsburgh Portland, Ore. St. Louis St. Paul Salt Lake City San Francisco Seattle Tulsa Washington
RESIDENT REPRESENTATIVES: Albany Baltimore Reading, Pa. Richmond, Va.
CROUSE-HINDS COMPANY OF CANADA, LTD., TORONTO, ONT. **CROUSE-HINDS INSTRUMENT COMPANY, INC., SILVER SPRING, MARYLAND**

(Continued from page 28A)

Promotion of five sales executives to key managerial posts has been announced by Pyle-National Co., Chicago. Manager of the Eastern Region is **H. F. Whalen**; **H. R. Weibel** has been appointed as Central Region manager; Western Region manager is **David Stiles.** Appointed to replace Mr. Whalen as New York district manager is **L. J. Milewicz,** and **J. M. Connell** will take over from Mr. Stiles as manager of the Philadelphia district.

Crouse-Hinds Co., Syracuse, N. Y. announces the appointment of **H. Paul Dees** as a regional manager in the Gulf Division, with headquarters at 2801 San Jacinto St., Houston, Texas. Under his supervision in the area are Corpus Christi, San Antonio, Austin, Beaumont, Longview, Lake Charles and Texarkana.

Crouse-Hinds has also named **James F. Wueste** as manager of the Washington, D. C. Region of the company. Mr. Wueste has been with the firm since 1939 and has been a product engineer since 1940.

Harold E. Kuehl has been named secretary of Garden City Plating and Mfg. Co., where he will supervise all administrative and financial matters. Mr. Kuehl joined the company in 1954 as assistant to the president.

Three representatives have been appointed by Quadrangle Mfg. Co., Chicago, Ill. **J. J. Roades Co.,** 3738 Washington Blvd., St. Louis, Mo., will represent the company in the southwestern part of Illinois, the eastern half of Missouri and the northwestern part of Kentucky. **Fred L. Shelor** has been named for the state of Virginia; his headquarters are at 109 Longstreet Ave., Highland Springs, Va. Representing the firm in Arizona is **John Allen Ware** & Associates, 4216 Commerce Station, Phoenix, Ariz.

Walter F. Powell, Jr., has been named manager of advance engineering for General Electric's Ballast Department in Danville, Ill. Mr. Powell joined G-E in 1950, and was most recently an electrical applied research engineer.

Harold A. Mosher, associate director of engineering at Kodak Park Works of Eastman Kodak Co., has been elected president of the National Society of Professional Engineers. He was installed, June 20, at the Society's annual banquet in the Hotel Commodore, New York City.

Dr. Leslie G. Cook has been named manager of Project Analysis Section of the General Electric Research Laboratory. He succeeds **Dr. Jenneth L. Kingdon,** who retired after 39 years with the laboratory.

Richard J. Gross has been named president of the Gross Electric Fixture Co., succeeding his father who died in March. Mr. Gross has managed the company's lighting division since 1952 and, for the past three years, has served as vice-president and wholesale operations manager.

Arthur J. Gambs, Jr., has been appointed sales manager of the American Device Manufacturing Co., in Steeleville, Ill.

Ira Newman, formerly with Swivelier Co., Inc., New York City, is now associated with Brazill Bros. & Associates, Inc., at 11-13 McKinley St., Linden, N. J.

The Board of Directors of N L Corp., Cleveland, Ohio, has elected **Maurice W. Terkel** as president and **George J. Klein** as chairman of the board. Mr. Terkel was most recently general sales manager and treasurer.

The N L Corp., has also appointed several new sales representatives: **Gerald Atherton-Ely,** San Diego, Calif.; **Anson C. Boyd,** Sacramento, Calif.; **Robert B. Cooper,** Billings, Mont.; **A. L. Greenland,** Philadelphia, Pa.; the **Jac & Meyer Co.,** Mount Vernon, N. Y.; **Gerald Marks** of Lighting Associates, Chicago, Ill.;

EMPLOYMENT OPPORTUNITIES

DIRECTOR OF SALES

Western Division—
One of the New Majors

Outstanding opportunity for 30-40 year old sales executive with demonstrated background of achieving goals through people. Will administer 15-man sales force reporting through two regional sales managers, manager of sales administration, pricing and quotations manager with a 5-man staff, and will be a member of policy-formulating staff group. West Coast Division is presently primarily engaged in fluorescent equipment manufacture and is one of 4 majors with approximately 15% of the market. Write for a job description. Send details of your background. Write Box 400, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

LIGHTING REPRESENTATIVES WANTED

Generous guarantee available for the right man to represent one of the largest, most diversified fixture companies in country. Following territories are open: Florida, Carolinas, (Arkansas, Tennessee, Mississippi) and Virginia. Only most qualified specification level representatives will be considered. Replies held in complete confidence. Address Box 393, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

REPRESENTATIVES WANTED

Newly founded incandescent lighting manufacturer in NYC has choice territories open for qualified lighting sales engineers. The line is new, quality equipment with advanced design features, for architect and engineer specification. Medium to high price range. 50,000 sq. ft. of modern facilities now operating. Completely equipped testing laboratory. Outstanding architectural lighting catalog. Strong, nonstop promotional help. Write territories covered and lines handled: President, Box 395, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

SALES REPRESENTATIVES WANTED

Expanding sales organization and product development offer exceptional opportunities with leading manufacturer of quality lighting for the church, commercial and institutional field. Line specified extensively in active, productive territories. Central and Southern Illinois, Kansas, Missouri and Arkansas are now available with nationally recognized progressive company in this field since 1905. Address Box 396, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

MANUFACTURERER'S REPRESENTATIVE WANTED

By nationally known midwest manufacturer of complete line of commercial lighting fixtures, fluorescent and incandescent. Also illuminated ceiling systems. Must know lighting and concentrate on architects and engineers. Territory, State of Iowa and adjacent states if desired. 100-page catalog with complete engineering information. Present representative retiring after 40 years. Our present representatives know of this ad. Address Box 398, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

POSITION WANTED

Available as Manufacturer's Representative or to manage Distributor's Lighting Dept. Ten years' experience in Baltimore-Washington area; college graduate. Contractor and professional following. Will relocate. Address Box 401, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

LIGHTING REPRESENTATIVES WANTED

Midwest manufacturer of quality, but competitive, fluorescent lighting equipment has openings for agents on a commission basis in the following territories: Texas, Kansas, Missouri, Carolinas, and New York State. We manufacture a large stock line and also deal in specials. Write, giving qualifications and lines now represented, to Box 397, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

REPRESENTATIVE WANTED NEW JERSEY

Major lighting equipment manufacturer, factory L.I.C., seeks experienced lighting salesman with imagination and good taste to call on architects and engineers. Knowledge of applied lighting and progressive techniques desirable. Opportunity for forward-looking individual to grow with organization having exceptional modern production facilities; comprehensive catalog and literature; photometric laboratory and esprit de corps unmatched anywhere. Address Box 399, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

LIGHTING SALES REPRESENTATIVE WANTED

By nationally known manufacturer of high quality specification commercial and institutional lighting fixtures (fluorescent and incandescent) and luminated ceiling systems. Qualified men should: 1. Know lighting and concentrate on architects and engineers; 2. Cover any of territories of: New York State, Louisiana, Illinois. We offer a modern product line, new catalog, illustrated detailed price sheet. Complete engineering information. We are Holophane licensees. Write full details to Box 388, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

T. A. Marshall, Miami, Fla.; **Frank R. Sandy,** Des Moines, Iowa; **A. W. Clark,** Salt Lake City, Utah; **Howell Carter,** Jackson, Miss.; and **W. D. Faust,** New Orleans, La.

NEW MEMBERS

At the meeting of the I.E.S. Council on June 18, 1959, the following were elected to membership. Names marked * are transfers from Associate Member Grade. Names marked ** are transfers from Student Member Grade.

ALABAMA SECTION

Associate Member:

Nunnally, L. H., Jr., Fluorescent Maintenance Co., Inc., Birmingham, Ala.

ARIZONA SECTION

Member:

*Baker, G. A., Baker & Moody, Phoenix, Ariz.

ARKANSAS CHAPTER

Member:

Deitz, C. E., Blaylock & Associates, Little Rock, Ark.

Associate Member:

Jinks, L. C., Jr., 652 Laughrun Drive, Forrest City, Ark.

BLUENOSE CHAPTER

Member:

*Matheson, D. T., Bryant Electric Co., Ltd., Halifax, N. S.

CENTRAL ILLINOIS CHAPTER

Member:

Baird, S. A., 903 Hamilton Blvd., Peoria, Ill.

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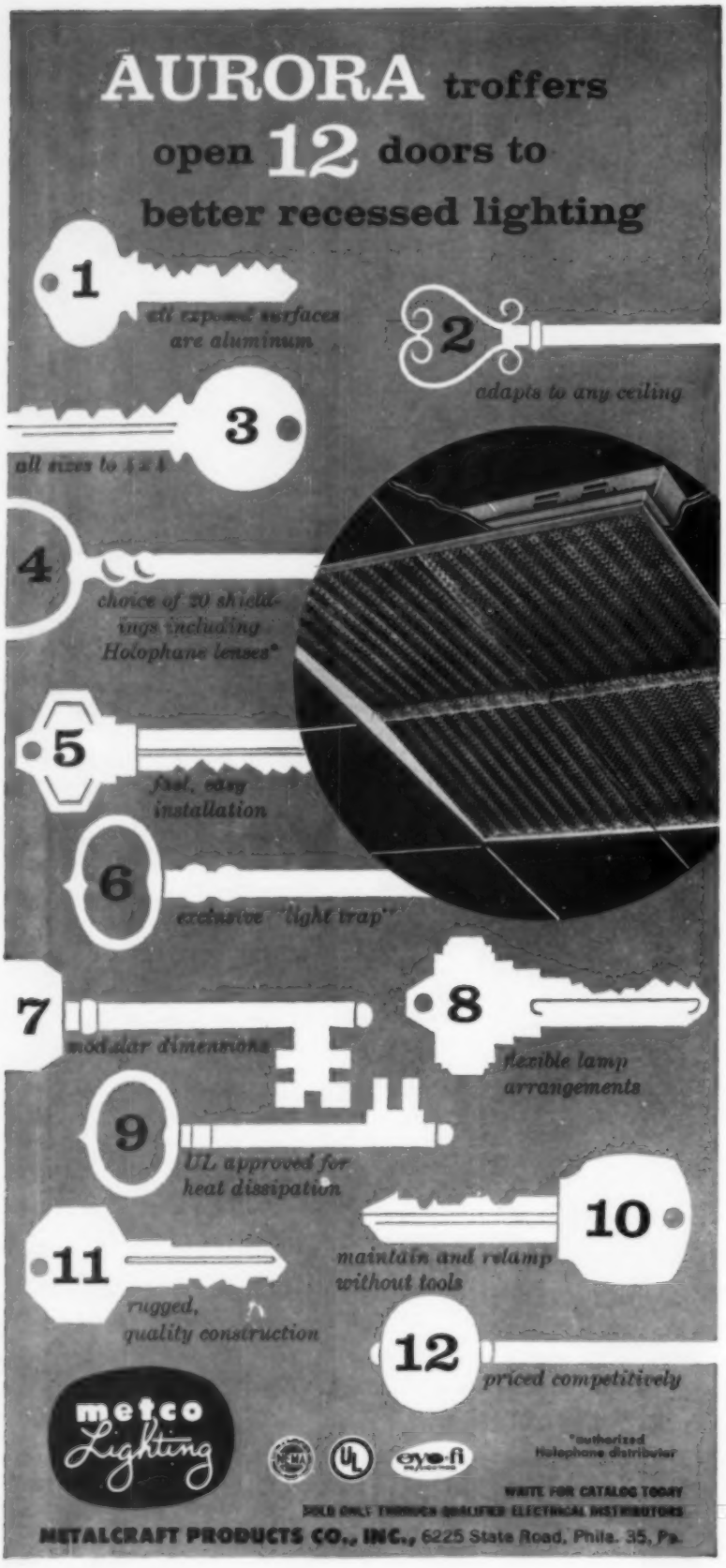

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